SILICON CHIP

FEBRUARY 2011
ISSN 1030-2662
02
PRINT POST APPROVED
- PP255003/01272
$9.30* INC GST NZ$11.25 INC GST

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Going Electric:
Mitsubishi's i-MiEV and Greenline's 33 Solar Hybrid

DMM Savings

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- 4000 count
- Data hold
- Diode test
- 10 A current range
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- Dimensions: 182(H) x 82(W) x 55(D)mm

QM-1326 WAS $79.95

$69.95 SAVE $10.00

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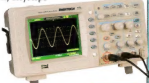

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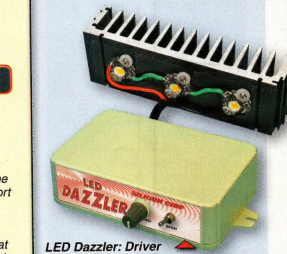

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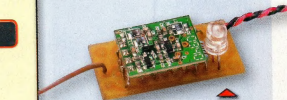

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SILICON CHIP
www.siliconchip.com.au

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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Noble Park, Victoria.

Distribution: Network Distribution Company.

Subscription rates: $97.50 per year in Australia. For overseas rates, see the order form in this issue.

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ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

In appreciation of old technology

As I write this editorial in early January, I am still in relaxation mode after a pleasant Christmas break. I hope that all our readers had a similar pleasant interlude and wish everyone a Happy New Year. Such interludes give you a chance to stop and take stock of how well your life is going.

For example, during one lazy Christmas afternoon spent with members of the family, the phone rang and I answered it. All very normal you would think but I happen to have a thing about old phones and the one I answered is a classic Australian-made black Bakelite unit with real mechanical bells and a rotary dial, similar to the one regularly slammed down by TV host Sean Micallef on his show "Talkin' about your Generation".

Why do I have such a museum piece? Apart from its appearance, it is mainly because I like the musical sound of its bells. They have a much more satisfying ring cadence than the classic American ring tones that many people have downloaded for their mobile phones and it dies away in such a realistic way – with a drawn-out "tinggggg" at the end – because they are real bells. By comparison, the piezo ringers in modern phones are shrill and quite unmusical.

Of course, talking for any length of time with one of those old phones soon reminds you how heavy that handpiece is. Nor can you even think about walking around the room while you talk; not only is the whole handset tethered to the wall via a short fixed cord, it is simply too heavy to carry for more than a short time.

Maybe this fascination with an old phone and its bells labels me as an oldie but it points to a time when phone calls were much more leisurely and something you only did when you really needed to. Why, there might be times when you wouldn't use the phone for days at a time! That would be unthinkable today when people feel deprived if they are without their iPhone and links to Facebook for more than a few minutes. They even have their phones with them while they sleep – just in case someone might make contact.

During our Christmas dinner some members of our group obviously felt that they had to immediately respond to text messages on their phones. And what if they hadn't? Would their world have stopped turning? In times past, if the phone rang and you didn't answer it, too bad.

Many of our readers have a similar attraction to Vintage Radio sets and enjoy listening to them rather than merely having them as display items. Old radios also have satisfying sound about them – vastly different from that of a Podcast via minuscule ear buds.

Similar comments can be made about people who like listening to vinyl LP records via valve amplifiers and large bass reflex loudspeakers – again vastly more satisfying than something downloaded into a player smaller than a matchbox.

It is good to have connections to and an understanding of old technology. In appreciating the achievements of the engineers and designers of yesteryear we have the ability to enjoy and marvel even more at today's rapidly changing technology. And yes, today's technology is very clever but look at what those old-time engineers were able to achieve with far less.

Another attraction in using old technology is that it gives great satisfaction knowing that it still works as good as new even though it might be more than 50 years old. Will today's consumer electronics products still be operational in 50 years' time? Highly unlikely!

If you understand old technology, there is a fair chance that you will have a better understanding or at least a good appreciation of the new. By contrast, younger people generally do not know (or care) how technology has evolved over the years. Being blasé about technology is all very well but you miss out on the feelings of wonder that life is so good with what we have now and what we didn't have only a few years ago.

Leo Simpson

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Audio delay needed for satellite broadcasts

May I add my support to Rob Chandler's letter (Mailbag, page 4, January 2011) concerning audio/video delay.

I am a regular viewer of Deutsche-Welle TV via AsiatSat3. The audio and video are seldom in sync. I have written to DW and predictably they responded that the problem was with the satellite operator. A software fix would be ideal, however my TV and PC are at opposite ends of the house.

Would you please give some serious thought to a hardware version which could be located beside my TV and its delayed output could be connected to the audio amplifier already connected to the TV line output. I don't have a problem with the cricket. As the ABC audio leads the video I have warning of an "event" and usually turn in time to see it happening on TV.

David Voight,VK3FDV,
via email.

Domestic lighting may be limited but other power demand is not

You may be assured that the design of our houses is in safe hands with the issue of the "Building Code of Australia 2010" taking effect from 2011.

I had a quick perusal of it at the local library and came to the conclusion that it did not specify that all houses had to have eaves, or that they had to be orientated so as to minimise heat gain from the Sun, or that they should not have an air-conditioning system installed, or that there was a limit on the number of flat screen TVs to be installed. There is also no limit on the floor area of the home, to restrict the building of "Mac Mansions".

However, the amount of fixed lighting that can be installed is limited to 5W per square metre so we can be sure that the house won't overheat from the lighting load and it will be environmentally sound! This lighting figure is mandatory and should it be exceeded by the electrician when he wires the house, he can be called back to rectify any lighting that does not comply.

Whilst 5W per square metre is not an onerous limit to work to, why has this been mandated when it would make no measurable difference to the production of greenhouse gases, particularly when there are other measures which would have a much greater effect as referred to in the second paragraph above? I see it as a completely unnecessary restriction on personal freedom.

Alex Brown,
via email.

Comment: this is yet another misguided attempt to control people's behaviour while not making any material reduction in overall domestic energy consumption.

Questions concerning broadband radar

I enjoyed reading the article on broadband radar in the November 2010 issue. If my reading is correct, the transmission is a narrow CW signal swept or stepped across a wide allocated part of the 3cm radio spectrum. This is tracked by the receiver and returns are processed and displayed according to the position of the rotating antenna; all very neat.

A note concerning the radio spectrum used by this device stated that it was not to be used for radar until 2010. I asked myself why! Well the device does get rid of interference. I was wondering if it also got rid of SART (Search And Rescue Transponder)

Eye-Fi now has ShutterSnitch application

That was a great letter from Laurie Bell (Mailbag, November 2010) and his discussion on the "progress" in modern electronics – especially things that don't remember their settings without power and DVD players that take forever to respond to front-panel button presses.

Regarding the DAB+ tuner project of October 2010, why is it so much better than other designs that also use the Venice 7 module? It is stated as a fact in the first few paragraphs of the article but not expanded on.

What don't the others do? How does the SILICON CHIP design "extract the very best sound quality possible out of every DAB+ broadcast signal"?

Regarding the Eye-Fi story in the October 2010 issue, back in about 2003 Nikon launched the WT-1 WiFi transmitter as an accessory to the D2H Pro DSLR which was great but it was a large external device mounting to the camera base and very expensive. The current Nikon WT-4 is more a belt-pack style, still over $1000 but may have better range than the Eye-Fi as it has an external antenna.

The Eye-Fi has brought the capability to a much wider audience at a great price. Check the link below to photographer Rob Galbraith's website on Eye-Fi use with an application called *ShutterSnitch* which receives and displays pictures wirelessly on an iPad, iPhone or iPod touch, moments after they're shot. It also has in-depth tips on configuration and on establishing a reliable connection between a camera transmitter (including the Eye-Fi card and Nikon & Canon WiFi devices) and ShutterSnitch: **http://www.robgalbraith.com/bins/multi_page.asp?cid=7-10055-10851**

David Boyes,
Gordon, ACT.

Comment: with regard to the DAB+ tuner, while most DAB+ radios provide similar facilities their sound quality generally leaves a lot to be desired.

NBN needs domestic back-up power

We hear a lot about the NBN rollout but never any mention of the equipment needed at the subscriber's end. I wonder if you could run an article concerning the interface equipment which will be required at the subscriber end. There must be plenty of information from places like Singapore and South Korea where they already have a fibre system – maybe even from Tasmania.

It seems to me that the subscriber will have to supply all power at their end as there will be no copper wire. All devices would need to have internal backup batteries in case of loss of mains power. In fact, will there be an option to only have a phone service if that is all you require or will everyone have a "standard" NBN modem which will allow any device to be connected? Any idea of the cost of this equipment would be useful.

Everything I have seen indicates that multimedia is the big ticket item regarding the NBN. It therefore seems logical that all TV and radio would eventually be sent via optical fibre rather than via RF transmission. That would save the TV stations erecting transmission towers all over the country – in fact they would not require all the frequencies which are allocated for different regions around Australia.

That would free up a lot of RF spectrum. If that were the case, does it mean that the "free-to-air" channels would still be free, even if you only wanted a phone system?

Ron Sanders,
Kiama, NSW.

Comment: indeed there has been quite a deal of comment in the mainstream media about this issue, even to the government's decision concerning payment for replacement of backup batteries in the event of failure.

transmissions and radio navigational beacon signals. Or is it possible to receive those signals via a secondary receiver or some other software inbuilt into the device?

This is not a small thing since the article says it is a navigational device. If it cannot receive radio location beacons or emergency transponders, then its use may be considered limited as a radar navigational device. Radar is useful but is only an aid, to be used with other methods for navigation. (I had the opportunity to sail in the company of a Master Mariner, who wrote the book "Radar Assisted Collisions". A copy was provided for every ship in the company, and it was informative reading).

Unfortunately, Australia has wide spans of neutral coastlines with radar returns that are featureless. This has been improved over the years by providing better charts, GPS, echo sounders and other radio navigational aids such as radar beacons at significant points, such as the start of a buoy channel.

I seem to be getting over-critical; the idea of low-power radar is very good. It would be magic if it could resolve all targets. As I have said before, it is only an aid and to this end any shortcomings should be noted. I digress; it is a bit like digital TV – perfect picture, clear sound or nothing. As opposed to analog, where multipath propagation, plus other faults can be diagnosed, by viewing the display.

It comes down to understanding the gains and losses in any system and letting them work for our purposes.

Trefor Jones,
East Fremantle, WA.

Comment: we do not know the answers to your questions and note that it was very difficult getting definitive information from the manufacturers during preparation of the article.

Circuit information wanted for old AWA PA amplifier

I have an AWA 20-watt transistor PA1004 amplifier model that I picked up from a recycler but I can't find any information on it at all. Google turned up zilch. Would you by chance have any leads I could follow up in at least getting something on this amplifier?

Ross Dalrymple,
Geraldton, WA.
dalrymple.ross@gmail.com
Phone 0450 216 366

Comment: we don't have any infor-

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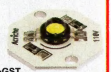

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Hand-held hot-wire cutter with PC power supply

The reason for this letter is because of John Clarke's revisit of the Hot-Wire Cutter project in the December 2010 issue.

I have constructed six units based on the original article in the April 2000 issue of SILICON CHIP. I made some changes, mainly cosmetic, the main one being a slot instead of a hole where the threaded rod is fixed to the vertical member. The allowed for adjustment of the length of the cutting wire. The wire used (from Dick Smith Electronics) was fixed at 250mm, allowing the units to be powered from redundant computer power supplies using the 12V output.

Modifications to the power supplies included: removal of the on-board fuse and installing a panel-mount safety fuseholder on the rear panel; removal of the multiple output cabling and replacing it with a single heavy duty wire for the 12V supply and the negative line; terminating these wires in a plastic jiffy box (with a plastic lid) fitted to the front panel; covering the fan guard with a square of aluminium flyscreen mesh; Lok-tite or super glue all the case assembly screws and adding a warning sign to the top of the case about the dangers of 240VAC inside. Five of these units are still operational after four years of use.

The last two supplies are a bit more complicated; as well as the 12V supply, the 3.3V rail has been used to power a hand-held cutter with a wire length of 100mm. The photo shows the details.

Keep up the great work with the best electronics magazine available.

John Warner,
Balgownie, NSW.

mation but we have published your email address and phone number, as arranged, so that any readers who do have information can contact you.

Replacement lithium batteries cheaper on eBay

Reading the article on the cordless drill in the December 2010 issue prompted me to write regarding my experience. I have a rather expensive lithium-ion battery drill and the batteries packed it in after not much more than 12 months. They cost about $90 each to buy and I needed two, so I opened the battery pack which was rather easy as the top was secured with three plastic clips. It contained three 18650E lithium-ion cells.

I searched the net and found them on eBay. A a pack of six (just what I needed) was available for $16.50, with free postage. After a bit of fiddling wiring them together I had two new batteries for the princely sum of $8.00 each. I can't help thinking that we are getting ripped off with some of these battery packs.

Paul Cahill,
Rooty Hill, NSW.

The Fischer Tropsch process for natural gas conversion

In your Publisher's Letter in the November 2010 issue you say the future for land transport in Australia lies in compressed natural gas. I would like to suggest the use of the Fischer Tropsch Process to convert natural gas to synthetic diesel or petrol.

The FT process converts mixed carbon monoxide and hydrogen (synthesis gas) to synthetic diesel or petrol at quite moderate temperature and pressure by the use of a catalyst. The carbon monoxide and hydrogen

can be sourced from natural gas, coal or even charcoal.

Nazi Germany used the FT process to make a large part of their fuel during World War II. South Africa also used it during the anti-apartheid sanctions. The FT output can be changed from diesel to petrol or alcohol by changing the catalyst. FT diesel can be very low in sulphur.

A. Mitchell,
Inverell, NSW.

Electrolytic Capacitor Reformer and Leakage Tester is a great project

My congratulations to Jim Rowe and SILICON CHIP for the electrolytic capacitor reformer project in the August & September 2010 issues. I've seen a small number of capacitor reformer designs in the past but none of those achieved the high levels of excellence in technical design, sophistication, utility, simplicity of use and safety that your project has achieved.

Since completing the construction of the reformer, I've already rescued numerous old high-voltage electrolytics (which I use in valve radio repairs) which would otherwise have been discarded because of high leakage currents.

Based on the leakage current table in the reformer article, a new, modern 8µF 450V aluminium electrolytic capacitor should have a maximum leakage current of around 400µA. However, what about older electrolytics, such as the power supply filter capacitors in the valve radios? Since the manufacturers of the earlier capacitors such as Ducon are now long gone and I place originality almost at the top of my priority list, my preference has always been to retain the original or similar capacitors wherever possible. Therefore, what upper level of leakage current would be deemed acceptable for these electrolytics?

As a long-standing practice, I have successfully reused high-voltage electrolytics which have a measured in-use maximum leakage current of around 5mA, on the key requirements that no internal heating of the capacitor takes place (ie, it does not show warmth in operation) and the measured capacitance value is still suitable for the job.

The *Radiotron Designer's Handbook* by Langford-Smith, Fourth Edition, page 193 states ". . . Electrolytic capacitors have an appreciable leakage current; this may be from 0.002 to 0.25mA per microfarad and varies considerably with the type of capacitor and the working voltage". Then, in *Modern Radio Servicing* by Ghirardi, First Edition, on page 594, it states ". . . However, in general, an 8 microfarad electrolytic filter capacitor rated at 450 volts should have a maximum leakage current of about 3 to 5mA".

These two statements provide assurances that some level of leakage current above the ideal is still acceptable in power supply electrolytics. Perhaps my 5mA figure does have a basis and

RF-based project building blocks wanted

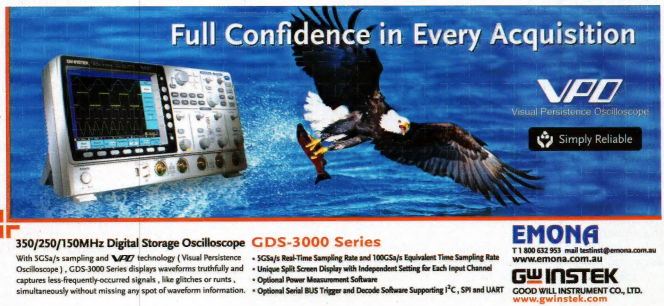
I would like to make a suggestion as to a set of new projects for SILICON CHIP. How about a set of RF-based project building blocks that could be assembled to provide different types of RF equipment?

For example, the building blocks could be different IF strips, filters, detectors (AM, FM, SSB etc), mixers, crystal oscillators, VFOs, BFOs, RF amplifiers, etc. These could be spread over different ranges in the RF spectrum to allow people to create receivers from VLF to SHF (if possible). There could be side-bars on the different types of modulation, comparison of single conversion over double conversion in receivers etc.

Depending on what you wanted to do with your receiver, you would use a different set of RF, mixer, oscillator, filter, IF and detector components to achieve the desired result.

These projects would be very useful. Those of us who have worked in RF in past would be able to come up to speed with the latest technology while those who have never had the chance would be able to become familiar with the concepts behind RF design and construction.

Laurens Meyer,
Richmond, Vic.



Mailbag: continued

Uninterruptible power supplies contain hazardous voltages

I recently repaired a Powerware UPS (Uninterruptible Power Supply) at the owner's home. Now the repair was simple but the ramifications of what I observed the owner attempting to do are very scary indeed.

The owner had disassembled the case, then reconnected the battery and began to test voltages; fine if you are extremely careful. However, he had then proceeded to poke into the components using his bare fingers or a metal nail file! Yes, the unit was turned on.

As far as he was concerned, the mains plug was out and this rendered the unit safe. How wrong he was. The battery was supplying the circuit with all it needed to supply 230VAC to the on-board power outlets and as such, he could well have been electrocuted. The in-built circuit breaker was a current-sensing type and only covered the incoming mains. The fuse on the circuit board was a blade type, soldered to the board and was rated at 40A – more then enough to kill.

This unit DID NOT have any type of residual current safety device although I have seen larger units that do. He argued with me regarding the safety of what he was doing until I ran my multimeter over the power points and his surprised look told me that he had learned a vital lesson.

So please, if you are working on any type of UPS system, disconnect the mains AND the battery or batteries. The very nature of a UPS is to supply 230V AC if the mains power fails or the voltage drops below a set point. In my experience, most may have 230VAC present on the negative battery terminal with the battery connected and the unit turned on. Don't take the risk!

Dave Sargent,
Maryborough, Qld.

may not be too far off the mark as a practical maximum?

One small point regarding the construction – I built the reformer using two smaller plastic parts boxes (approx. 300 x 200 x 50mm) screwed together, one on top of the other (the type with removable separators, also from Bunnings) The top box contains the circuit board and the front panel (with the 12V DC power connector on one side) and normally spends its life fully closed. The bottom box contains the safety microswitch, the test leads and the space for the capacitor.

By building the project this way, should a capacitor decide to explode, its internal contents will quickly become external contents(!), showering the inside of the bottom box with "goop"! However, as the capacitor and its contents are fully contained within the bottom box, no harm results to the components in the top box because of the separation provided.

In conclusion, I have no doubt your project will become globally recognised and built since there is absolutely nothing like it elsewhere for the home constructor. Thank you for a well-designed and most useful project.

Graeme Dennes,
Bunyip, Vic.

Comment: as far as leakage in high-voltage electrolytic capacitors is concerned, the original manufacturers' specifications for electrolytic capacitors from companies such as Ducon, UCC, Philips and others only specified the minimum performance (ie, the minimum specification guaranteed by the manufacturer) and not what is acceptable for long life or for that matter, how much leakage can be tolerated in a particular valve circuit.

We think your approach is eminently practical: "If it doesn't get noticeably warm, then it is probably OK". If you do a quick calculation of 5mA @ 450V, it means that the capacitor is dissipating about 2.25W – again, probably OK for a relatively large capacitor but too much in a small can size.

Construction tip for ultrasonic anti-fouling project

I have just constructed six of the Ultrasonic Anti-Fouling kits from Jaycar for three of my friends (my boat lives in dry storage so I don't have a problem) and I have enjoyed it greatly (best day at work for a long time).

When mounting the glands on the side of the 50mm pipe fitting (for the transducer housing), I found it easier to drill and tap it with a 12mm 1.5 tap and use PVC pipe glue on the threads for extra bonding.

Russell Kelly,
Archerfield, Qld.

Adding digital control to a valve guitar amplifier

I would really like to see an article on possible ways of controlling the settings on a valve amplifier with a digital interface. I am particularly interested in retrofitting a guitar amplifier for MIDI automation.

The main reason I want to do this is that valve amplifiers are only really capable of doing one sound at a time. In order to add extra sounds we need to add more channels, more tubes, more knobs and all the relevant switching circuitry.

Unfortunately, this makes our amplifiers way more expensive, not to mention bulkier and heavier to carry around. But what if we had a method of utilising each channel on an amplifier to its fullest potential?

What I mean by this is that it would be nice to replace those tired old analog potentiometers on the front panel (Gain, Low, Medium, High, Presence, Volume, etc) with some kind of digitally controlled equivalent. We could then use a microcontroller to remember any favourite settings and to change programs on-the-fly at our command.

This idea is quite exciting because this would allow us to plug in many different types of guitars and effects without having to manually change the amplifier's settings to get the right sound. The modern musician also requires many different sounds, all in the space of a single song, hence the need for some kind of programmable interface. Program changes can be triggered from a MIDI pedal board and received by a MIDI interface at the amplifier.

As a keen guitarist and self-confessed gear hoarder I have spent some time looking into possible ways of trying to retrofit an amplifier with some

kind of digital potentiometer and as you would expect it's not very straightforward. The US company Mesa Boogie has a nice little solution which they use in their famous Tri-Axis preamps (US Patent 5,208,548). This solution uses LDRs to provide a resistive element to replace a traditional analog potentiometer. It uses these to control Gain/Distortion levels, EQ settings etc.

The patent is worth downloading from the net and is an essential and entertaining read for anyone interested in this kind of thing. What I like about this design is that it uses a closed loop to always guarantee that the resistance across the LDR is bang on with every setting, so you are guaranteed the same sounds every time you switch the amplifier on.

To modify (and maybe even improve) this design would have been good. However, there are a number of problems for the average enthusiast. The LDRs (Hamamatsu HTV-P873) that they use are next to impossible to obtain. Finding a replacement dual-element LDR isn't easy as they either don't exist or you have to buy them in lots of 1000 if you can find a source.

If we opt for a single-element LDR how do we make sure the resistance across it is correct? We can't use a transistor as the resistive element due to the fact that silicon doesn't like really high voltages as valves do. Digital pots in ICs generally don't seem to have the right range of resistances for the job either.

Primarily, what we want from a solution is:
(1) Fast switching time (around 10-20ms or so);
(2) Noiseless switching;
(3) Minimal tone colouration;
(4) Good repeatability to get the same sounds we need every time;
(5) Enough resistances to get good control over the amplifier (ie, 32 or more, the Tri-Axis only has 16);
(6) Must be able to handle the high-gain settings in modern rock music without introducing too much noise.

Some readers may ask why I haven't mentioned motorised pots. This is because they are very expensive, a bit slow to change settings and difficult to fit inside an existing amplifier chassis. I have already built a modular PIC-based MIDI receiver for this project. Thus I am less interested in that side of things and more interested in creating a "digital potentiometer".

Paul Matthews,
Wyndham Vale, Vic. SC

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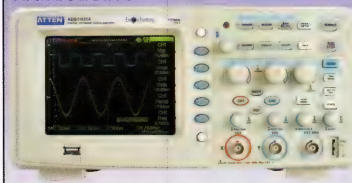

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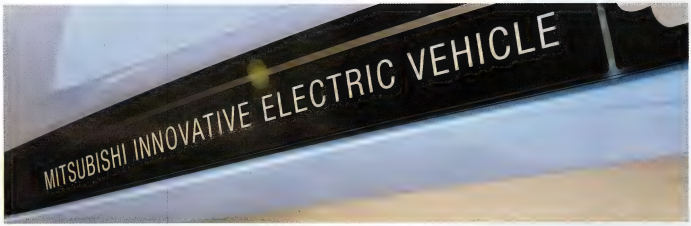
Perhaps the most remarkable thing about the Mitsubishi i-MiEV is that it is so unremarkable. It is a fully electric vehicle but more importantly, it is a compact hatchback that can transport four adults practical distances in comfort, after just a few hours of charging.

We drive Mitsubishi's i-MiEV Electric Car

by Nicholas Vinen



Do you think that practical electric cars are still in the future? We had a ride in this one which has already been in use on Sydney's streets for a few months. It is being evaluated by Roche Pharmaceuticals Australia, on a special lease from Mitsubishi Motors.

Our demo ride was organised by Malcolm Faed, whom readers may remember from the article on his electric ute conversion (SILICON CHIP, June 2009).

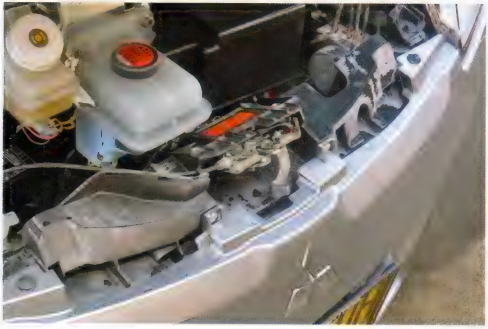
Besides the lack of engine noise and the large lettering advertising the fact, you would be hard-pressed to tell that it is an electric car. Acceleration is comparable to that of a petrol engine of around 1.3L, as is typical for cars of this size.

All the usual accessories are present: air conditioner, heater, radio and CD player, satellite navigation, anti-skid power brakes, power-assisted steering, HID headlights, keyless entry and so on.

Other than to say that performance is perfectly adequate, two facts that you need to know about this car is its range (around 100km) and its charging

(Left): under the floor of the small boot lies the battery charger/inverter and motor controller. These are normally hidden by the boot floor. They do get rather warm in operation, hence the warning signs (we wouldn't leave the ice cream in the shopping bags too long in the boot, either!).
(Below): lifting the bonnet reveals . . .not a great deal! For a start, it's tiny and there's no motor under here. But what you do get are the various fluid reservoirs (just like a normal car!), the service battery (just like a normal car!), air conditioner (just like a normal car!) and so on.

time, seven hours from a standard 230VAC 15A mains outlet or under an hour with an external 3-phase 50kW quick charger. For most city commuters, these figures make it a practical proposition.

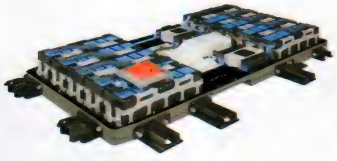


Impressions

Riding in it for the first time, we noted good visibility all-around and a small turning circle. Internal space is adequate, with sufficient headroom for all but the tallest occupants although leg room is restricted. The boot is small but will fit a large suitcase or several bags of groceries.

Mitsubishi have put in some nice touches such as motorised folding side-mirrors and a windscreen washer system which sprays water on the windshield from the single large articulated wiper arm. The dash is uncluttered and is dominated by the digital speedometer, battery gauge and large navigation/radio control screen in the centre.

Not only is the electric engine very quiet but road noise is also kept well under control. We measured below 60dBA at 60km/h with the air conditioner fan at a medium setting. In fact the most obvious noise while driving is the occasional sound of the brake assist vacuum pump. It runs for a second or so after pulling up at traffic lights. It is not particularly loud but is noticeable, simply because the car is quiet.



The multi-cell lithium-ion battery pack is rated at 16kWh and when charged, delivers 330V. It is located under the centre of the vehicle.

There are nowhere near as many readouts showing the state of the electric drive system as compared to the Toyota Prius or some other hybrid/electric cars.

We don't think this is a disadvantage; the i-MiEV has displays for bat-

The motor and transmission are somewhat hidden up under the rear of the vehicle on the rear axle, as this photo shows. There is no reverse gear as such. Immediately above the motor is the charger/inverter, with the battery pack forward.

tery charge state and estimated range remaining. Anything more than this could be a distraction for some drivers!

Our brief drive of the car was on a warm summer morning with temperatures in the high 20s. The air conditioning did provide some cooling but with the large windows we're not sure how comfortable it would be on a hot sunny day.

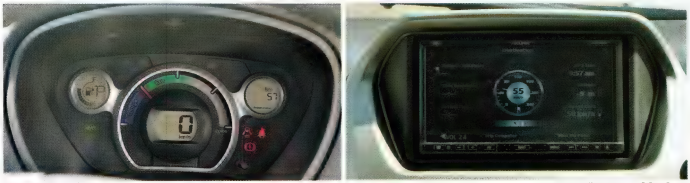
Since the AC draws around 1kW from the battery pack, it will reduce the range by 5-15%, depending on the outside temperature (ie, compressor duty cycle) and trip duration.

Technical details

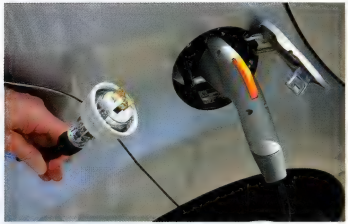
The i-MiEV is externally quite similar to many other four-door compact hatchbacks and is in fact derived from a Japanese Kei car ("light automobile"), the Mitsubishi i. The main points of difference are the Lithium Polymer battery between the floorpan and seats, the electric motor and transmission on the rear axle and the battery charger and controller fitted under a hatch in the boot.

The motor is a three-phase permanent magnet synchronous type which produces 47kW and 180Nm. It is driven from a variable frequency and voltage inverter for speed control, which is named the MCU or Motor Control Unit. There is no reverse gear; to go backwards the motor simply spins in the other direction.

As can be seen from the graph below, while the motor is not particularly powerful, it has excellent torque at low RPM and this provides quite good acceleration from a stand-still. Top



The dashboard would not be unfamiliar to anyone driving a conventional vehicle. The gauges might need a second look, though, especially the "fuel" gauge. In the centre of the dash is the large LCD display which is essentially GPS information (with a beautiful big map!) but it can also be programmed to display other vehicle information.



There are two methods of charging. At left is the mode most people will use, from a standard 230V 15A power outlet plugging into the on-board charger. This takes about seven hours to charge the batteries to 100%. But if you're in a real hurry and can find a 3-phase, 200V 50kW charging station (not here yet!), the socket on the right will charge the batteries to 80% in 30 minutes.

speed is around 130km/h.

The battery pack weighs 230kg and has a capacity of 16kWh at 325V. According to Mitsubishi the vehicle's range is 160km but once traffic, heating and cooling, headlights and so on are taken into consideration, it will be closer to 100km.

To get the fastest charge rate (from flat to 80% capacity in 30 minutes) you need a 3-phase, 200V 50kW "Japanese Quick charger" which connects to the passenger-side charging port. Since these will only be provided in major cities, most users will instead charge the vehicle from a 230V 15A mains outlet via the driver's-side charge connector.

Both connectors are covered by flaps just like those used on petrol or diesel cars.

The controls are just like those of a regular automatic car. As well as the usual Park, Reverse, Neutral and Drive positions, the "gear" lever also has an Economy setting which limits motor performance to increase range and a Brake position which provides regenerative braking.

This is comparable to engine braking in a petrol or diesel engine, with the added advantage that some of the vehicle's kinetic energy is returned to the battery to charge it "on the run". This will obviously increase the vehicle's range.

The heater and cooler are both driven from the main battery pack although the circulation pump for the heater runs from the 12V service battery (located under the bonnet).

The electric element heats a fluid identical to internal combustion engine coolant (ethylene glycol and water) and this in turn heats air.

Like the drive motor, the air conditioner compressor is also a permanent magnet brushless type, with its own inverter.

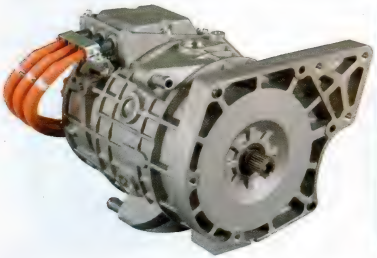
Benefits

While the most obvious benefit of having an electric car is never needing to go to a petrol station, there are other reasons to want one.

One significant advantage is that it requires little maintenance. Occasional servicing is necessary as there are fluids to replace (transmission oil, heater coolant etc) but there are relatively few moving parts so maintenance costs should be low.

The relative simplicity of electric motor drive also means there is far less to go wrong than a petrol car. There is no fuel pump, no gearbox, no radiator, no head gasket to blow and so on.

Of course, it is possible that the inverter or controller (or some other



The electric motor is a permanent magnet, synchronous type rated at 47kW. It can produce 180Nm of torque for good low-speed acceleration

And here's another view of the on-board motor controller shown earlier, obviously out of the vehicle (in fact, on display at a show).

significant component) could fail but we doubt it will be a common occurrence.

In fact the largest maintenance expense is likely to be the eventual replacement of the battery pack once its useful life has been exhausted. Testing by Mitsubishi shows that the battery pack retains over 80% of its original capacity after 1,000 charge/discharge cycles.

This suggests that the pack will last at least five years for a typical commuter and probably longer.

Bottom line

Some readers will be asking themselves: where can I get one and how much does it cost? We have some bad news for you. There aren't many i-MiEVs on the road outside of Japan and they are all on special leases. That may change in a few years but for now, they are not available to the general public in Australia.

As for the price, the vehicle costs around AUD $45,000 in Japan and we would expect them to cost at least that much when they are sold here.

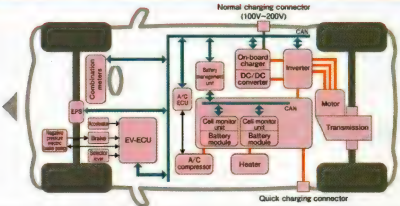
It isn't all bad news, though. Competition is on its way to the plug-in electric vehicle market. As we are writing this article, Nissan are delivering the first production LEAF electric cars in Japan and North America. The LEAF has a similar size, range and cost as compared to the i-MiEV, with a more powerful motor (80kW). It costs $35,000-$47,000 (depending on where it is sold).

While these new electric cars are definitely practical, their limited availability and high price are the biggest obstacles to widespread adoption. As time and technology marches on, that should change. SC

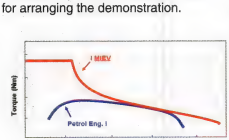
Acknowledgement: thanks to Roche Products Pty Ltd and Malcolm Faed for arranging the demonstration.

SPECIFICATIONS

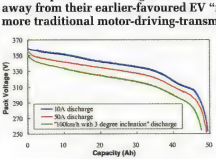
• Electric Motor: (10.15 mode, gross weight 1,250kg)	Permanent Magnet Synchronous, 47kW 180Nm of torque (from stall) Maximum Output (kW/rpm) 47/3000-6000 Maximum Torque (Nm/rpm) 180/0-2000 Power Consumption (W.h/km) 125 Range (km) 160km
• Batteries	High capacity 330V lithium-ion 16kWh capacity
• Charging Time	230V (15A) Connection: seven hours to 100% 3 Phase 200V 50kW connection: 30 mins to 80%
• Drive Modes:	D – optimised performance E – optimised economy B – optimised regenerative braking
• Dimensions & Packaging:	Overall Length 3395mm Overall Width 1475mm Overall Height 1610mm Wheelbase 2550mm Front Wheel Track 1310mm Rear Wheel Track 1270mm Seating Capacity 4 people
• Standard safety features:	Reinforced Impact Safety Evolution (RISE) body construction ABS brakes Dual front airbags Traction Control
• Claimed running cost:	1/3 that of a conventional (petrol) vehicle 1/2 that of a petrol HEV 1/9 that of a petrol vehicle when charged at off-peak rates



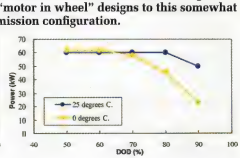
The basic configuration of the i-MiEV electrics. It relies heavily on the CAN bus and computer monitoring and control. With the i-MiEV, Mitsubishi have gone away from their earlier-favoured EV "motor in wheel" designs to this somewhat more traditional motor-driving-transmission configuration.



Low-speed torque of the iMiEV compared to a conventional (petrol) engine. Maximum torque is at zero rpm.



Battery capacity (and discharge) depends a lot on the way you drive and also the terrain (hills!) encountered.



Change in motor power as the battery discharges is affected significantly by temperature. (DOD= Depth of Discharge).

A new experience in power boating – hybrid electric power

Greenline ± HYBRID

Many people have a love of boating. But boaties tend to fall into one of two camps, sail or power – and the two seldom see eye-to-eye. Power boaties find yachts a problem because they always seem to demand right of way (even when not under sail!) and yachties turn their noses up at power boats for being noisy, smelly and so on – they call 'em "stink boats".
But what if there was a power boat that could also appeal to yachties? There is: the Greenline 33.

By LEO SIMPSON

With a casual glance inside the Greenline 33 you'd never know it was one of the most innovative craft on the water – you'd just think it was typical of the many luxury cabin cruisers available. It's only when you "lift the lid" you find it's not quite as it seems!

The Greenline 33 *is* a power boat but it is a power boat with a major difference – it is a hybrid.

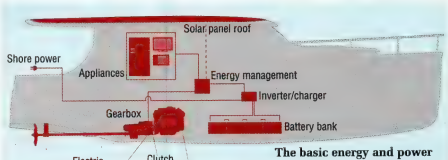
In some ways it is like a hybrid car, in that it has an internal combustion engine and an electric motor. But the drive set-up is quite different to car hybrids like the Toyota Prius, Camry, Honda Civic, Lexus 450h and others.

Whereas most car hybrids can only drive a very short distance on electric power alone, if at all, the Greenline 33 can go for many hours when powered solely by its lithium-polymer batteries; 20 nautical miles at 5.5 knots in fact.

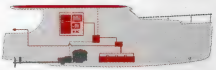
But even more impressive, it can run at about 2.5 knots under solar power alone. So while ever the Sun is shining, it can just keep going under electric power. And when the Sun goes behind heavy cloud or you want to move along faster, you can start the diesel engine and really motor along at up to 15 knots.

But while this boat can move at a very good pace, it does not have a planing hull and it does not gulp fuel when it is being pushed.

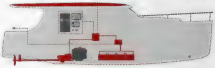
In fact, at low speeds its fuel consumption is similar to that of a 30-ft



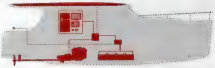
The basic energy and power plan of the Greenline 33, with the various modes at right.



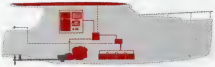
Shore power mode – the boat is plugged in to 230V AC with battery charging etc.



Electric drive – powered by electric motor via batteries, solar panel and/or generator if req.



Diesel drive – engine drives boat and charges batteries with up to 5kW output.



At anchor – solar panel provides 230V AC power; diesel engine can provide charging.

Left: even with all the Raymarine electronics covered for protection, it still looks pretty much like a typical boat helm with throttle mounted on the starboard bulkhead. However, look a bit closer (right pic) and you'll notice that big "hybrid switch" in the middle of the dashboard. Now that's not something you see every day!

yacht when under power. Powered by the diesel alone, its range is up to 700 nautical miles. That would get you from Sydney to Hobart!

First impressions count . . .

As I write this, I have just returned from several very pleasant hours on Sydney's Pittwater in the Greenline 33.

And while I came away from the trip with many impressions, the overriding characteristic of the boat is its silence.

Under electric power it makes no more noise than a yacht under sail and even when running with the diesel it is very quiet. In fact, it can be called serene.

So as you can see, it can potentially appeal to yachties and power boaters alike. Yachties will particularly like its serene progress while power fans will like the fact that it just sips fuel while still being able to move along at quite a good rate when required.

Details

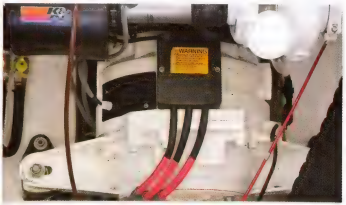
The Greenline 33 is a single cabin cruiser with an overall length of 9.99 metres. In hybrid form it is powered by a diesel engine with the top option being a marinised VW TDI 125kW 2.4-litre 5-cylinder unit.

The accompanying electric motor is rated at 7kW. This is mounted in line with the diesel engine and drives the single propeller via a standard forward/reverse gearbox.

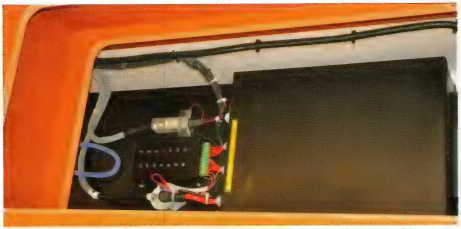
The major difference between the Greenline 33 and typical hybrid cars is that in the boat, only one motor can drive the propeller shaft. In hybrid cars, the petrol motor and electric motor can both contribute power at the same time.

Hence, with the Greenline you could elect to leave your berth or mooring under electric power, moving virtually silently and with no wake. Depending on the state of the batteries you could run at up to six knots or up to 20 nautical miles (at a speed of four knots).

If you wanted to get to your destination faster, you could change over to diesel. To do this, you must stop the electric motor and start the diesel. This has glow-plug ignition so it takes



At left is the 2.4 litre, Volkswagen TDI 165-5 5-cylinder Diesel power plant, with the 7kW electric motor sitting behind it (enlarged view above). You have the choice of powering the vessel with the diesel engine only, with the electric motor powered by batteries and/or roof-mounted solar panel, or with the electric motor with the diesel running in generator mode to keep the batteries charged. (You cannot run with both the diesel and electric motors running together; a clutch disconnects the diesel engine when running under electric power).



Even with the hatch up, most of the electrics (as distinct from electronics!) is hidden from view, under cover for protection against wandering hands. This is actually the 48V 240Ah lithium polymer battery and battery management system.

a short time to start. Then, you switch over to diesel and a clutch connects the diesel to the electric motor and the combination drives the prop shaft via the forward/reverse gearbox as before.

However, now the electric motor becomes a generator with a rating up to 5kW and it charges the two 48V lithium polymer batteries which have total rating of 240Ah.

Incidentally, being a lithium-polymer battery, it is considerably smaller and lighter than an equivalent lead-acid battery. It weighs about 140kg whereas an equivalent capacity lead-acid battery pack would weigh as much as one tonne.

Being a power boat owner myself, I was continually making comparisons between the Greenline and my boat. As already noted, the silent progress of the Greenline is the big point – under electric power it is almost eerily silent, depending on wind and wave conditions of course, but much quieter than any conventional power boat.

The only time a "normal" power boat would be comparably quiet would be with the engines switched off!

The other point of note was the lack of exhaust fumes. It's not widely understood that a normal power boat of this type can suck carbon monoxide or other noxious exhaust gases back in through an open cabin rear door while under way.

Because there are no fumes in the Greenline, this means that you could travel with the cabin completely open and not worry about breathing in dangerous fumes.

In fact, you can troll along at just a knot or two, with the large transom panel swung down to form a swim platform or you could have a fishing line or two in the water, to catch your meal. Magic!

Mind you, the comment about lack of exhaust also applies when the Greenline is under diesel power because the exhaust is under water (wish mine was too!).

Super displacement hull

Another point to note is that Greenline functions very well under electric power or even a smaller diesel engine because it has a patented "super displacement" hull which slides through the water more like a yacht than a conventional displacement hull.

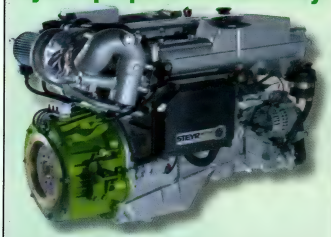
That's not just advertising hype, it really is a different type of hull.

While the Greenline cannot achieve the high speeds of a power boat with a planing hull, it can still move along at a maximum of 15 knots, which is considerably more than could normally achieved from a displacement hull with a water-line length of about 9.5m.

In fact, "hull speed" for a displacement hull of that length is about 7.5 knots so the Greenline with its 125kW diesel can double that speed. And it can do that speed with much less fuel consumption than a similarly sized

This photo wasn't included to demonstrate the nautical prowess of the author (you might have noticed the boat is still at its berth!) but to show the roof-mounted 1.3kW solar panels which are quite capable of powering the boat along at a steady 6 knots in sunlight (or a little less under cloud). At right is the integral OutBack Power Systems energy control unit. It's showing 65.4V @ 0.4A input with 53.6V at 0.5A output. Note the bank of semicondutors alongside!

Hybrid propulsion from Steyr



While the Greenline 33 with its VW diesel is currently the only production hybrid pleasure motor boat available in Australia, there are other diesel hybrid systems for boats such as those from Steyr Motors GmBH, Austria.

Steyr Motors have three diesel/electric hybrids available. Pictured is the MO256H45 which combines a 6-cylinder 3.2 litre turbo-charged diesel rated at 184kW (256 BHP) teamed with a 48V 7kW electric motor.

This has four modes of operation. In the Starter mode, the diesel engine is started by the electric motor while in the generator motor, the electric motor is driven by the diesel to charge the batteries.

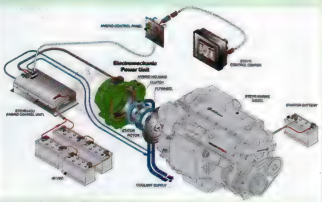
In electric cruise mode, the boat is driven purely by the electric motor while the battery pack is constantly monitored by the Steyr Control Centre.

Finally, in boost mode, the diesel's power is augmented by the torque of the electric motor, depending on the demands of the driver and the battery condition.

The other two models available are the MO144M38, a 4-cylinder, 2.1 litre turbo-charged 106kW (144 BHP) diesel, teamed with the same 7kW electric motors and the MO94k33 sail-drive unit which combines a 66kW (90 BHP) 4-cylinder 2.1 litre turbocharged diesel and the 7kW electric motor. The sail-drive unit is intended for use in yachts.

At last year's Sydney Boat Show we understand that the 6-cylinder 184kW hybrid unit drew a lot of interest from police and customs agencies who liked the possibility of an electric "stealth mode" – it could be a real surprise for water-borne law-breakers!

For further information, contact Steyr Motors Australia, 33 Stone Street, Stafford, Qld 4053. Phone (07) 3356 9808. www.steyr-motors.com.au



planing boat. So electric or not, the Greenline 33 is a very economical boat to run.

On the other hand, with its single propeller, the Greenline is not quite as manoeuvrable as a twin-engine boat which can typically be spun on the spot (with one motor in forward gear and the other in reverse).

To partly address that drawback, there is an optional Side-Power SE40 bow thruster which really does help when you are berthing the boat. Interestingly, the bow thruster has its own 12V battery and is not powered by the main lithium-ion batteries which run the electric motor.

Electrics

Having just mentioned the bow thruster, we should give some more information about the rest of the electrics. Another option on the Greenline is the 1.3kW solar panel array on the cabin roof. This charges the lithium batteries via a 48V solar battery charge management system.

There are two other 12V batteries; one for the aforementioned bow thruster and the house battery which runs the cabin lights, instruments, pumps for water in the cabin and toilet/shower, anchor windlass, transom and so on.

There is also a 48V to 230V AC 3kW inverter which provides power to run the air-conditioning and other nice

Most unusual to see on a vessel this size – a full size fridge with freezer. In the foreground is a microwave oven and immediately above that an induction cooktop. Gives some idea of the luxury fittings you'll find on the Greenline!

Specifications (as reviewed):

Length overall:	**9.99m**
Beam overall:	**3.49m**
Draft loaded:	**0.70m**
Displacement empty:	**4800kg (approx)**
Cabins:	**1 plus saloon (sleeps 4/5)**
Toilets/washrooms:	**1**
Diesel tank:	**430l**
Water tank:	**300l**
Engine:	**VW Marine TDI 165-5**
Max speed:	**15 knots**
Speed under electric power:	**6 knots**
Range (elect. drive @ 4 knots):	**20nm**
Design:	**J&J Design**
Engineering & development:	**Seaway**
CE Cat:	**B**
Price:	**$333,333**

features such as the full size fridge/freezer, microwave oven, ceramic cooktop, two 22-inch LCD TVs, DVD player and the list goes on.

The solar panel can easily maintain the batteries on full charge if you are on a mooring (ie, away from mains power). If you do have 230VAC shore power available on a berth, you can use that to run the systems while you are tied up.

The local agents tell me they never bother with shore power since the solar panel is more than adequate for the job, except for the occasions when the batteries need mains power for "balancing" (roughly once a month).

By the way, when you are away from shore power, anchored in some secluded bay or inlet, you can also use the diesel engine and electric motor-cum-charger (with 5kW output) to charge the batteries and run all your appliances, including the air-con.

This is the so-called "anchor" mode of the Greenline and is identical in principal to those large power boats which have an on-board petrol or diesel-powered generator, typically rated at 5kVA or more. The difference is that the Greenline does not need an additional heavy generator plus starting battery (maybe 300kg or more) which normally sits there idle.

What more can I say? There is much more to interest any boatie, like the luxurious standard of finish and inclusions – on a par with our European boats such as Beneteau and Jenneau but we have covered the main technical points.

It can be purchased as a basic diesel-powered boat at $243,333 or can be fully optioned up as described in this article, with solar panel, hybrid electric package etc, for $333,333, both prices including GST.

For my money, the full Greenline 33 hybrid electric package would be the one to go for. You have all the benefits of silent electric power, minimal fuel cost, low engine maintenance and you still enjoy all the mod cons of a big power boat. Bliss on the water.

For further information, contact Mark Whitman, North South Yachting Australia Pty Ltd, The Quays Marina, 1856 Pittwater Road, Church Point, NSW 2105.

Acknowledgement: our thanks to Mark Whitman and staff at North South Yachting for their assistance in the preparation of this review. SC

Lithium-Ion batteries have big advantages in boats

Up till now, virtually all batteries for boats have been lead acid variants and these have the disadvantages of massive weight, physical bulk and are easily damaged if they are over-discharged.

The massive weight is a double disadvantage in that it takes a lot of fuel to drag around in a boat and it also is a huge problem when a lead acid battery has to be replaced – getting heavy batteries out of cramped engine compartments is back-breaking work, usually involving two men.

By contrast, lithium-ion batteries are a great deal smaller and lighter and can be subjected to a much greater depth of discharge.

Compared with a typical lead acid battery which can only be subjected to a recommended depth of discharge of 50% (meaning a 400Ah battery can only deliver 200Ah), lithium-ion battery can be subjected to an 80% depth of discharge.

Furthermore, the capacity rating of a lithium-ion battery is usually not affected by the rate of discharge – it has the same capacity whether is discharged over a period of one hour or 20 hours.

But until recently, lithium-ion batteries were not available in the large sizes needed for boats. Now they are. Mastervolt has two: the MLI24/160 and the MLI2/320.

As you might have guessed, these are 24V @ 160Ah and 12V @ 320Ah, both equating to 3.84kWh. They weigh just 45kg, 70% less than an equivalent lead acid battery pack and 70% smaller, as well.

They have a very long lifespan with greater than 2000 charge cycles and charge efficiency is also much higher than typical lead acid units; 90 to 94% compared to 70 to 83%.

The battery packaging provides completely isolated battery terminals and they can be connected in series up to 250VDC or in parallel.

OK, so they are a lot more expensive than lead acid batteries but the overall advantages can outweigh the higher cost. You can work with a smaller capacity battery, you get much longer battery life (up to triple the life-span) and overall efficiency is much higher.

For further information, contact Mastervolt Australia, 30 Beach St, Kippa-Ring, Qld 4021. Tel: (07) 3283 7800; Website: www.powersolutions.com.au

Dick Smith - Your Comple

Lab Power Supply 0-30V 2.5A with Digital Display
Laboratory grade linear power supply with 0-30V adjustable output and an adjustable constant current setting from 0A to 2.5A at all selectable output voltages. Features separate voltage and current metering, overload protection and high/low current front panel terminals. Solidly built chassis, measures 150mm (W) x 235mm (D, inc knobs) x 145mm (H, inc feet). Not carried in all stores, but can be ordered in. Q1770

$99

SAVE $50

Dick Smith 1-15V DC 60A Heavy Duty Lab Power Supply
High efficiency Lab supply with adjustable 1V to 15V DC output, huge 60A continuous current rating, plus low ripple output and internal cooling fan. Front and rear panel DC outputs, with a remote sensing terminal to compensate for cable losses. Features large LED front-panel metering and heavy-duty rear panel banana sockets. Limited stock. Not carried in all stores, but can be ordered in. Q1775

$249

SAVE $50

CLEARANCE

Deluxe Dual Input Thermometer
Compact, dual input 4.5 digit digital thermometer, complete with 2 x K-type sensors. Offers both Celsius and Fahrenheit readings. Beeper sounds when preset temperature limit is exceeded. Also includes Relative mode, Min/Max readings, and Auto Power Off function. Limited stock. Not carried in all stores, but can be ordered in. Q1417

$59

SAVE $40

Digital Sound Level Meter
A quality digital sound level meter with auto and manual ranging plus a fast digital bar graph. Provides metering of 40dB to 130dB SPL with A and C weighting. Includes fast and slow metering response, Min/Max recording, and Auto Power Off function. Great for checking sound levels in factories, schools and offices. Not carried in all stores, but can be ordered in. Q1562

$69

SAVE $50

Wide Range IR Thermometer with Laser Marker
Measure an object's temperature remotely with this sensitive IR thermometer. A quality IR sensor and lens (distance to spot ratio of 8:1) minimises the surface area required for accurate readings over the -50°C to 538°C range. Inbuilt laser marker, backlit LCD screen, Auto Power Off and Data Hold functions. Not carried in all stores, but can be ordered in. Q1370

$69

SAVE $30

CLEARANCE

ABS Instrument Case
These high impact ABS plastic cases have a two part design with a tongue groove joint. They are lightly textured for a low scratch surface and maintain a high quality finish. Features guide slots for vertical mounting of PCBs. 140 x 110 x 35mm (W.L.H). Limited store stock only. Not available for web or mail order sales. H2512

$3.99

SAVE $4

CLEARANCE

Sealed Polycarbonate Boxes
With tongue/groove sealing system, neoprene gasket, and stainless lid fixing screws. Limited store stock only. H2860

FROM $4.99 EA

SAVE $5

80 x 82 x 55mm. H2869	$4 SAVE $5
90 x 115 x 55mm. H2863	$4 SAVE $5
121 x 171 x 80mm. H2867	$9 SAVE $5

Personal Visor Magnifier
Great for working with small components, jewellery or circuit boards. Selectable 1.8x, 2.3x and 4.8x magnification, adjustable headband and integral illuminating lights (batteries required). Not carried in all stores, but can be ordered in. Batteries required, not supplied. H4914

$19.99

SAVE $10

Dick Smith 389pc Crimp Terminal Kit
This high quality kit includes a wide variety of crimp-style terminals stored in a handy re-usable case with 18 compartments. See www.dicksmith.com.au for a full list of the included terminals. Not carried in all stores, but can be ordered in. H3063

$29.97

SAVE $10

Looking for your nearest Dick Smith store?

Head to dicksmith.com.au!

te Technology Destination

CLEARANCE

Dick Smith Digital Display 55W Soldering Station
Professional 55W soldering station with lightweight soldering pencil, flexible cabling and a plated soldering tip. Adjustable temperature range of 200°C to 450°C, large LED style temperature metering, plus a long-life ceramic heating element. Limited store stock only. Not available for Web or Mailorder sales. Limited store stock only. T3230

$69
SAVE $60

LIMITED STOCK

Dick Smith 1000A AC/DC True RMS Digital Clamp Meter
This industrial grade meter features a large 4000 count LED screen with bar graph display, AC/DC current ranges to 1000A, and Auto Power Off function. True RMS AC voltage and current readings provide greater accuracy when measuring non-sine waveforms. Not carried in all stores, but can be ordered in. Q1476

$98
SAVE $70

$12.99
SAVE $7

Dick Smith 60W Soldering Iron
Provides extra heat reserves for those larger jobs. With 240V operation, 470°C operating temperature, long-life plated tip, lightweight handle and a mini soldering iron stand. T2309

$49.98
SAVE $20

PRO-70K Butane Solderpro Kit
Cordless 70W butane soldering iron kit, soldering tip plus Hot knife, 'heat blower' and blow torch tips, solder, cleaning sponge, handy carry case. Not carried in all stores, but can be ordered in. T1105

$128
SAVE $20

Weller PSI-100K Butane Soldering Iron Kit
Pro grade butane tool with piezo self ignition, stainless steel body, complete with a range of high quality iron-plated tips and solid plastic case. Not carried in all stores, but can be ordered in. T1398

$4.99
SAVE $3

Solder 0.8mm 100g Roll
General-purpose electronics-grade flux-cored 60/40 (tin/lead) solder suitable for most projects and repair work. 0.8mm size, 100g roll. Not carried in all stores, but can be ordered in. Limit of 2 rolls per customer. X2628

Dick Smith Freeze Spray
Ideal for use in the electronic, automotive and engineering fields. It instantly cools small components to assist with detecting thermal problems such as faulty joints. 250g can. Non-flammable. Not carried at all stores, but can be ordered in. N1122

$6.97
SAVE $10

Dick Smith Contact Cleaner
An aggressive contact cleaner for use in cleaning metallic switch contacts in the general electronics area eg. TVs, PC boards, computers and phones. Not for use with plastics. Highly flammable. 190g can. Not carried at all stores, but can be ordered in. N1124

$6.98
SAVE $8

Anti-Static Solder Sucker
Easy to clean solder sucker with a strong metal body, excellent suction and a heat-resistant Teflon tip. Not carried in all stores, but can be ordered in. T2507

$6.99
SAVE $8

Offers starts 24/01/11 and ends 28/02/11 or while stocks last. All offers are for retail store stock only, with strictly limited stock available. Some items may not be available for mail orders, stock movements between stores and back orders. No rainchecks. No fayby. Enthusiast electronic items are not available in all stores. Offers may not be available in some reseller or franchise stores. Please contact your local store to determine availability.

dick smith
Talk to the Techxperts

By NICHOLAS VINEN

LED DAZZLER

Caution: these LEDs are so bright they will burn your eyeballs!

WE'RE NOT JOKING about the warning. Even a brief glance at these white LEDs while they are operating at full power will leave spots before your eyes for quite a while afterwards. **They are blinding and they do hurt your eyes. We definitely do not recommend looking at them for even the briefest glance. You wouldn't look at a laser – well don't look at these either!**

And don't be fooled into thinking that the light output is in a narrow beam; the built-in optics do an excellent job of distributing it over a wide area, with a viewing angle of 130°. So even if you are well off-axis, they are painfully bright.

Until now, you might have thought that a 50W halogen lamp was pretty bright but these LEDs are much brighter (at 900 lumens) and they use a fraction of the power – just 10W. It doesn't take a mathematical genius to realise that this means big energy savings. At the time of publication, these are the brightest LEDs you can get (as far as we know).

They are made by Seoul Semiconductor in Korea and they go by the utterly prosaic description of type W724C0-D1. Their rated brightness is 900 lumens, with a colour temperature of 6300K and a colour rendering index (CRI) of 70. Careful examination shows that they consist of four LED dies connected in parallel under a plastic lens which does a good job of focussing the light.

However, this is all academic if you have no way of driving them. LEDs are quite difficult to drive correctly, especially when they need 2.8A at 3.6V. They require an efficient current source, otherwise the high efficiency of the LEDs can be spoiled by wasteful driving circuitry.

This project will drive up to six of

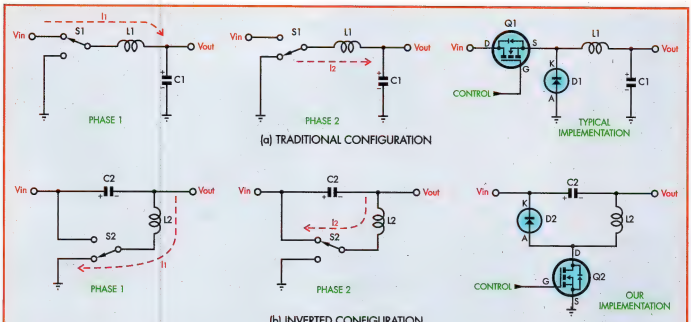


Fig.1: the typical buck step-down regulator configuration (top) compared to the inverted configuration used in this circuit. In each case, the current flow is indicated during the two phases as I1 and I2.

these dazzling LEDs (depending on supply voltage) and it also provides dimming. The efficiency of the circuit is up to 94.5% (see Figs.2-4). The operating supply voltage range is from 12-30V.

This design will power virtually any high-brightness LED (1W, 3W, 5W etc) from a low-voltage DC supply, including both white and coloured types. It incorporates a low battery cut-out for 12V or 24V batteries to prevent over-discharge, a standby switch and an integrated fuse.

The challenge

Driving high-power LEDs is tricky. If driven just below their nominal forward voltage, little current will flow and not much light will be produced. Conversely, if driven just above their nominal forward voltage, they can overheat and burn out.

The traditional approach is to use current-limiting resistors and a voltage source such as a 12V battery. This works but it wastes power in the current-limiting resistors and also has the disadvantage that the brightness of the LEDs varies quite markedly with relatively small changes in the supply voltage. As a result, it is much better to drive these high power LEDs from a regulated current source.

This new design is a switchmode step-down regulator that uses a single high-current Mosfet. Each 10W LED requires 2.8A at 3.6V and so with a 12V supply, you can drive three 10W LEDs in series. Or with a 24V supply, you can drive up to six LEDs.

Unlike some other LED driver circuits, this one needs no adjustment to suit different LED types, except to change one resistor to set the amount of current they require. Hence, this driver circuit is suitable for driving virtually any high-power LED, including those from Cree and Luxeon.

Where to get the LEDs

These 10W LEDs are available from RMS parts (**www.rmsparts.com.au**) as Item Code W724C0-D1. At the time of writing they cost $26 each plus GST (less for bulk purchases).

Also available from RMS Parts (but not listed on their website) are the small aluminium PC boards which are used to mount them. These have Item Code STAR-P7 and are available at additional cost (contact RMS Parts for more details).

Heatsinking

The biggest problem with high-power LEDs is heat. Without an adequate

Specifications

Input voltage	12-30V
Output current	0-3A
Input current	Up to 3A
LED power	1-10W each
Number of LEDs	1-3 (12V supply), 1-6 (24V supply)
Efficiency	Up to 94.5% (see graphs)
Drop-out voltage	0.5V
Features	Dimming, standby switch
Line regulation	<4% output variation over 12-30V
Temperature regulation	<3% output variation under typical conditions
Low battery cut-out settings	12V, 24V or disabled
Low battery cut-out, 12V setting	11.5V (negative-going), 12.0V (positive-going)
Low battery cut-out, 24V setting	23.0V (negative-going), 24.0V (positive-going)
Low battery cut-out current	<1.5mA for 12V, <2mA for 24V

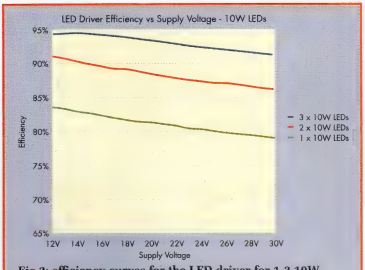


Fig.2: efficiency curves for the LED driver for 1-3 10W LEDs. The efficiency is higher with more powerful LEDs and with more of them connected in series.

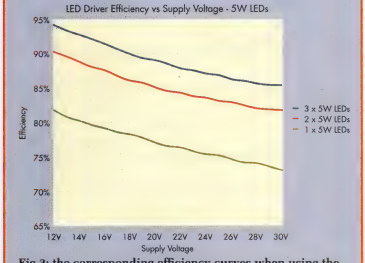


Fig.3: the corresponding efficiency curves when using the driver with 5W LEDs. Note that for supply voltages above 16V, more than three LEDs can be driven in series and this will further increase the efficiency.

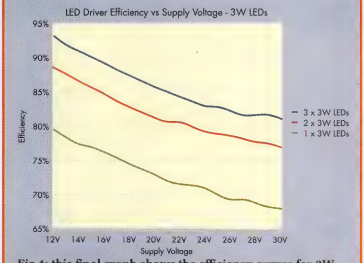


Fig.4: this final graph shows the efficiency curves for 3W LEDs. The efficiency exceeds 90% for three 3W, 5W or 10W LEDs for any supply voltage below 15V.

heatsink they get stinking hot and can be destroyed in a very short time. Even if you don't run the LEDs hot enough to melt them, if they are operated at a high junction temperature, they will have a short life. So an adequate heatsink is very important.

Our prototype set-up used three LEDs running from 12V. We also used a single, large heatsink (Altronics H0550), with the LEDs mounted 50mm apart via the above-mentioned STAR-P7 boards. They are secured using M3 x 6mm machine screws into tapped holes, with Nylon washers to prevent the screw heads from shorting the mounting boards to the heatsink.

We will give more details on this later.

Switching circuit

As noted above, the particular virtue of this LED driver circuit is its exceptional efficiency (up to 94.5%). This is achieved by an unusual switchmode configuration which regulates the LED current (to gain a good understanding of how current regulators work, see the separate article in this issue).

Our circuit (see Fig.5) involves an N-channel Mosfet (Q4) driving a string of LEDs connected to the positive rail. We control the LED current with sensing resistor R1 which is between the LEDs and the positive rail. R1 is monitored by comparator IC5 and in conjunction with latch IC4b, controls the duty cycle of the switching pulses applied to the Mosfet.

Refer now to Fig.1(a) which shows the traditional "buck" step-down configuration. This uses a switch (or switches) to alternately connect one end of an inductor (L1) to the positive supply rail and ground.

It works like this: when the inductor is connected to the positive rail (phase 1), current flows through the inductor to the load, charging up the output capacitor (C1) and storing energy in the inductor's magnetic field. The rate at which the current increases is limited by the inductor.

When the switch changeover occurs (phase 2), current flow from the positive rail is interrupted and so the magnetic field in the inductor begins to collapse and the stored energy is then fed to the capacitor and the load. Again, the rate at which the current through the inductor decreases (and how the magnetic field collapses) is limited by its inductance.

The proportion of time that current flows from the positive rail is the duty cycle and this controls the output voltage. This approach is efficient because the energy stored in the inductor's magnetic field when S1 is connected to the positive rail is returned later, rather than just being converted to heat (as with a linear regulator).

The circuit on the righthand side of Fig.1(a) shows a typical arrangement using a Mosfet (Q1) and a diode (D1) as the switching elements.

Now take a look at Fig.1(b). These circuits are similar to those shown in Fig.1(a) but the polarity is reversed. The output voltage is now relative to the positive rail instead of to ground and this is how we have arranged the "LED Dazzler" driver circuit, because we wanted to use an N-channel Mosfet (as they are superior to P-channel Mosfets).

With the traditional arrangement shown in Fig.1(a),

when Mosfet Q1 is on, its drain and source are at the positive supply potential. As a result, its gate must be driven at a higher voltage for it to stay on and this usually involves a charge-pump voltage booster circuit.

The inverted arrangement gets around this problem since the Mosfet's source is tied to ground and no boost circuit is necessary.

Efficiency

As can be seen from Figs.2-4, the efficiency is excellent for three LEDs driven from a 12-16V supply. It is highest for the 10W LEDs and drops off with increasing supply voltage.

For high supply voltages, the efficiency can be improved by adding more LEDs in series. As a general rule, the number of LEDs that can be used is equal to the supply voltage divided by four and rounded down.

The efficiency depends largely on the regulator duty cycle. At lower duty cycles, the switch-off time is longer. During this time, the "flywheel" diode (D1) is forward biased and its forward voltage (around 0.55V) represents a significant loss. Inductor core eddy current losses are also higher because the inductor's ripple current increases.

For a single LED with a forward voltage of 3.6V, the voltage loss across the flywheel diode is about 15% of the output voltage (note: energy is also lost in current sense resistor R1 used in the final circuit but this depends only on the output current).

Circuit details

Now take a look at the complete circuit shown in Fig.5. As mentioned earlier, the driver is a current regulator. We'll start by describing the switching portion of the circuit, at right. Its main components are current sense resistor R1, inductor L1, Mosfet Q4, Schottky diode D1 and capacitor C1.

When Mosfet Q4 is switched on, current flows through a path equivalent to phase 1 in Fig.1(b), ie, from the positive supply input, through fuse F1 and resistor R1 and then through the LED string, inductor L1 and Mosfet Q4 to ground.

Conversely, when Q4 is switched off, current circulates in a loop (phase 2) through R1, the LED string, inductor L1 and diode D1.

Voltage drops are minimised by using a low-value current sense resistor (R1), a low-value inductor (with low DC resistance), a high-current Mosfet and a Schottky diode. This improves efficiency and also means that we can run three 10W white LEDs with an input voltage of just 12.1V. With 2.8A flowing, the input-output voltage differential (drop-out voltage) is just 0.5V.

The 1nF capacitor and 22Ω resistor between Q4's drain and ground form a "snubber". Basically, when Q4 switches off, it "shocks" the resonant circuit consisting of inductor L1 and any stray capacitance, creating a high-frequency burst which can produce electromagnetic interference (EMI). The snubber damps the resulting oscillations, without having much effect on switching (see Fig.8).

Parts List For LED Dazzler

1 PC board, code 16102111, 118 x 74mm
1 flange-mount plastic case (Altronics H0121)
4 No.4 x 9mm self-tapping screws (supplied with case)
1 PC-mount SPDT right-angle toggle switch (Altronics S1320)
1 knob to suit 9mm potentiometer (eg, Jaycar HK7734)
1 spring washer for VR1 or two flat washers
3 M3 x 10mm machine screws
3 M3 shakeproof washers
3 M3 nuts
1 47µH or 100µH 3A inductor (Altronics L6517 or Jaycar LF1272)
2 PC-mount M205 fuse clips
1 4A M205 fuse
2 2-way terminal blocks (Altronics P2034A)
1 Micro-U TO-220 heatsink (Jaycar HH8502, Altronics H0630)
1 6-pin 2.54mm pitch header (snap into 2 x 3-pin lengths)
2 jumper shunts
2 small cable glands for 3-6.5mm cables (Jaycar HP0720, Altronics H4305)
1 small cable tie
10cm 0.71mm diameter tinned copper wire
1 length of twin-core high-current cable (eg, Jaycar WB1754) to suit installation
1 1kΩ linear 9mm potentiometer (VR1)
1 5kΩ horizontal trimpot (VR2)

Semiconductors

1 LM358 dual low power op amp (IC1)
1 LM285Z-2.5 or LM385Z-2.5 voltage reference (IC2)
1 NE555/LM555 timer (IC3)
1 CD4013 dual CMOS D-type latch (IC4)
1 LM311 high-speed comparator (IC5)
1 78L12 linear regulator (REG1)
2 BC327 transistors (Q1, Q3)
1 BC337 transistor (Q2)
1 IRF540N Mosfet (Q4)
1 IRF1405 Mosfet (Q5)
1 1.5KE36CA or similar 33V AC TVS (TVS1, Jaycar ZR1177)
1 STPS1545F Schottky diode (D1) (Altronics Z0065)
1 1N4148 signal diode (D2)
2 15V zener diodes (ZD1, ZD2)
1 5mm red LED (LED1)

Capacitors

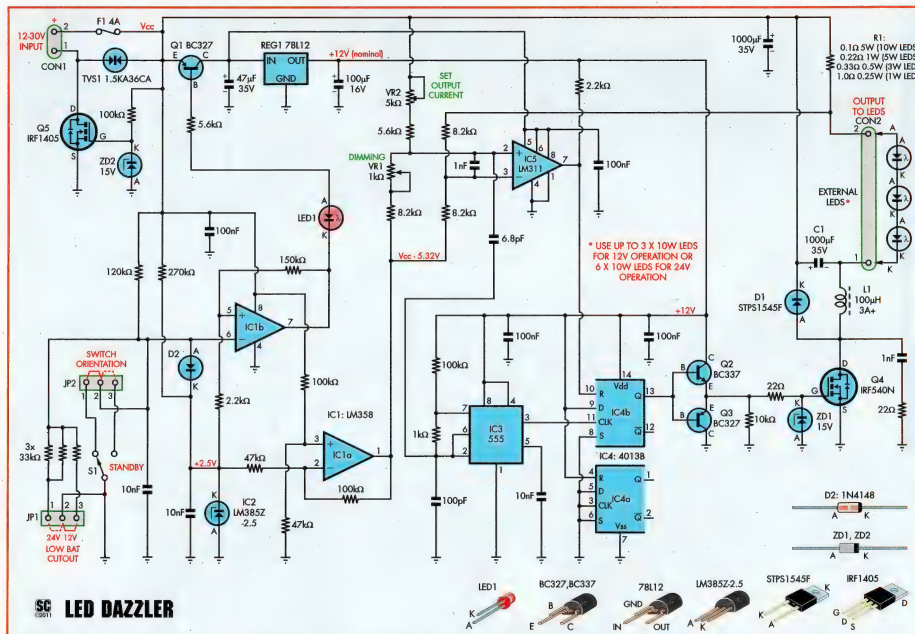
2 1000µF 35V electrolytic (Altronics R5185) or 2 x 470µF 35V low-ESR electrolytic (Jaycar RE6338)
1 100µF 16V
1 47µF 35V
4 100nF MKT
3 10nF MKT
2 1nF MKT
1 100pF ceramic
1 6.8pF ceramic

Resistors (0.25W, 1% unless stated)

1 270kΩ
1 150kΩ
1 120kΩ
4 100kΩ
2 47kΩ
3 33kΩ
1 10kΩ
3 8.2kΩ
5 6.6kΩ
2 2.2kΩ
1 1kΩ
2 22Ω
1 1Ω (for 1W LEDs)
1 0.33Ω 0.5W (for 3W LEDs)
1 0.22Ω 1W (for 5W LEDs)
1 0.1Ω 5W (for 10W LEDs)

Control circuity

Our first prototype used a switch-mode controller IC (a TL3843) to control Q4. However, while this is a logical approach, converting the current flow to a feedback voltage for the IC introduces a delay and we could not get it to operate smoothly under all conditions.



LED DAZZLER

Fig.5: the complete circuit diagram. The LEDs are driven by a switchmode circuit comprising inductor L1, Mosfet Q4, diode D1 and capacitor C1. This is controlled by IC4, a CMOS latch, which is in turn controlled by IC3, a 555 timer and IC5, a high-speed comparator. IC1, a dual low power op amp, provides a reference voltage for the comparator and also switches the circuit off if the battery voltage is low.

In the end, we solved the problem by designing a switchmode controller using several common ICs. As well as solving the delay problem, this controller also has a maximum duty cycle of 100% which reduces the drop-out voltage.

By contrast, common switchmode controller ICs have a typical maximum duty cycle limit of 90-95%.

The switching frequency is determined by 555 timer IC3 which is configured in astable mode and runs at 68kHz with a 99% duty cycle. The duty cycle is set by the associated 100kΩ and 1kΩ resistors, while the frequency is set by these two resistors and the 100pF capacitor on pin 2. The reason the duty cycle is so high is described later.

IC3's pin 3 output is connected to the CLK input (pin 11) of IC4b, which is half of a CMOS dual latch IC. This latch controls the regulator's duty cycle. With the data input (pin 9) held high, when the CLK pin goes high, the latch is "set" and the output (pin 13) also goes high.

This drives an emitter-follower buffer stage formed by transistors Q2 & Q3 which in turn drive Mosfet Q4. This buffer stage ensures that Q4 switches quickly despite its gate capacitance (2nF) and is necessary for the Mosfet to operate efficiently at 68kHz.

The 10kΩ resistor to ground ensures that Q4 switches off when not actively driven, while the 22Ω resistor forms an RC filter with Q4's gate capacitance to prevent gate voltage overshoot. Zener diode ZD1 protects Q4 against excessive gate voltage.

Q4 switches off when IC4b's reset input (pin 10) is pulled high, causing its output (pin 13) to go low and turn Q2 off and Q3 on. Q4 remains off until the next timing pulse from IC3, provided the reset pin is not still high (as it could be). If that pin is high when IC3's output goes high, the latch is not set and that pulse is skipped entirely.

Current comparator

As noted previously, the sensing resistor R1 is connected between the positive rail and the LEDs. The current through this resistor (and thus the LEDs) is monitored by IC5, an LM311 high-speed comparator. It controls the reset input of latch IC4b, which is pulled up to 12V by a 2.2kΩ resistor.

While ever the voltage on IC5's inverting input (pin 3) is higher than at its non-inverting input (pin 2), its pin 7 output is low and so the latch is not reset.

However, when the voltage at pin 2 is higher than at pin 3, IC5's output goes high, resetting the latch (IC4b) and thus switching off Mosfet Q4. The latch provides hysteresis, so the comparator circuit needs none.

The inverting input (pin 3) of comparator IC5 is connected to the lower end of current sense resistor R1 via a divider network made up of two 8.2kΩ resistors. This gives the divider a ratio of 1:1. If powered from 12V, IC5's valid input voltage range is 0.5-10V. The divider keeps the inputs within this range.

The lower end of the divider is connected to a reference voltage which is at Vcc - 5.32V, where Vcc is the supply voltage. Since one end of R1 is connected to Vcc, in order to keep the division ratio constant, the reference voltage must be relative to Vcc.

The comparator's non-inverting input (pin 2) is also connected to a voltage divider, one end of which is at the same reference voltage as before, (Vcc - 5.32V). Its upper end is connected to Vcc via trimpot VR2, while brightness adjustment potentiometer VR1 is in the lower section of the divider.

When the LEDs are not lit, there is no voltage across R1, so pin 3 of IC5 is at Vcc - 5.32/2 = 2.66V below Vcc. With VR1 at its minimum setting (ie, maximum resistance), the divider at pin 2 also has a ratio of 1:1 (assuming VR2 is trimmed correctly) and so IC5's non-inverting input will also sit at about Vcc - 2.66V.

As VR1 is turned clockwise, its resistance drops and the voltage at pin 2 of IC5 is reduced. As a result, IC5's output switches low and releases the latch reset on IC4b. Mosfet Q4 then switches on at the next clock pulse from IC3 (ie, when pin 13 of IC4b goes high and turns on Q2). When it does, current through the LEDs increases and so does the voltage across R1, in turn reducing the voltage at pin 3 of IC5.

When the current through the LEDs is high enough, the voltage at pin 3 of IC5 will be lower than at pin 2, causing the comparator's output to go high. This then resets the latch and turns off the Mosfet. As a result, the current through the LEDs is regulated to a level controlled by the settings of VR1 and VR2.

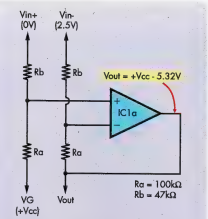


Fig.6: a simplified differential amplifier composed of an op amp and four resistors, two each of two different values. Its output voltage is calculated as Vout = VG + (Vin+ - Vin-) x (Ra/Rb).

Note that if VR1 goes open circuit, Q4 will switch off. Worn pots can sometimes go open circuit so it's important for the circuit to "fail safe" in this condition.

Frequency compensation

The 1nF frequency compensation capacitor between IC5's inputs is critical, as it rolls off the comparator's frequency response. It forms an RC filter with the resistors in the two voltage dividers and limits the rate at which the two input voltages can vary.

Without it, the regulator's duty cycle can swing between extremes on a pulse-by-pulse basis. For example, consider a scenario where we want a duty cycle of 50%. Without the capacitor, the average current through the LEDs may be correct but with the duty cycle oscillating between 25% and 75% at every other pulse.

This is undesirable because it can generate sub-harmonics at a fraction of the 68kHz switching frequency, some of which are at audible frequencies. The resulting magnetostriction can result in an annoying high-pitched whine from the inductor. With a stable duty cycle, this does not occur.

The 6.8pF capacitor connected between pin 2 of the 555 timer (IC3) and pin 2 of the comparator (IC5) also helps stabilise the regulator. The timing ramp of the 555 timer is a sawtooth pattern and the capacitor AC-couples this signal into the feedback, thereby providing "slope compensation".

This is why IC3 has a high duty

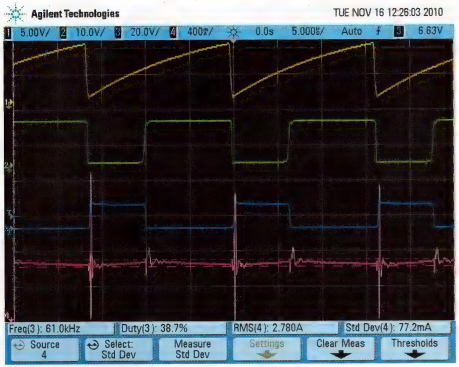


Fig.7: the yellow trace is the sawtooth waveform at pin 2 of timer IC3, the green trace the comparator output at pin 7 of IC5, the blue trace Mosfet Q4's gate drive and the pink trace is the current through the LEDs. The frequency has been lowered because of probe capacitance. Current through the LEDs builds while Q4's gate is high and decays while it is low. The positive edge of the comparator output (green) corresponds with Q4 switching off (blue) and the beginning of the timer ramp (yellow) corresponds with it switching back on.

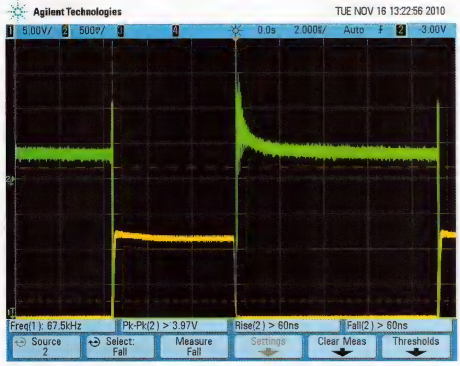


Fig.8: the green trace at top is the voltage across flywheel diode D1, while the yellow trace at the bottom is Mosfet Q4's gate waveform. When Q4 switches off, the diode becomes forward biased and quickly clamps the rising voltage from the inductor. A small amount of ringing can be seen when this occurs, which is quickly damped by the snubber. After a short period, the voltage across D1 drops to below 500mV despite carrying a few amps.

cycle; it results in an appropriate waveform for compensation.

The result is that the switch-off current threshold is slightly lower at the end of each pulse than at the beginning and this eliminates duty-cycle "hunting".

Reference voltage circuit

The Vcc - 5.32V reference in this circuit is derived from a 2.5V reference voltage by op amp IC1a, which is configured as a differential amplifier. Fig.6 shows a simplified version of IC1a's circuit. Its output is the difference between its two inputs multiplied by its gain and that output can be shifted by a predetermined offset voltage which we will refer to as "VG" (virtual ground).

In our case, the differential amplifier's inputs are connected to two voltage dividers, each consisting of resistors Ra & Rb. These dividers set the gain of the amplifier and since Ra is 100kΩ and Rb is 47kΩ, the resulting gain is about 2.13.

So let's plug in some values. VG is in fact Vcc, Vin- is the 2.5V reference (provided by IC2) and Vin+ is tied to ground (ie, 0V). So the output voltage is:

$$Vout = VG + (Vin+ - Vin-) \times Ra/Rb$$
$$= Vcc + (0 - 2.5V) \times 2.13$$

Simplifying this gives:

$$Vout = Vcc + (-2.5V) \times 2.13$$
$$= Vcc - 5.32V$$

Low battery cut-out

IC2 is an LM358Z-2.5 (or LM258Z -2.5) shunt regulator and this provides the 2.5V reference for IC1a. It is also used by IC1b for the low battery cut-out detector. This "micropower" voltage reference diode has 1-3% accuracy (depending on the part used) and operates with a current as low as 10μA.

The 2.5V reference is fed to pin 5 of IC1b, its non-inverting input, via a 2.2kΩ resistor. The 2.2kΩ and 150kΩ feedback resistors provide hysteresis (0.5V for a 12V supply and 1.0V for a 24V supply). This prevents the circuit from rapidly switching when the supply voltage is marginal, due to feedback caused by the voltage drop along the supply leads.

The supply voltage (Vcc) is divided and applied to pin 6 of IC1b (ie, to its non-inverting input). The division ratio is set by jumper JP1. For 12V batteries, the ratio is 120kΩ:33kΩ and the low-battery cut-out voltage 11.5V. For 24V batteries, the ratio is

120kΩ:16.5kΩ and the cut-out voltage is 23V.

When Vcc is above the threshold, the voltage at pin 6 of IC1b is higher than at pin 5, so its pin 7 output goes low. As a result, current flows through LED1 and its 5.6kΩ current-limiting resistor. This turns on PNP transistor Q1, supplying current to IC5 and regulator REG1.

If Vcc drops below the negative-going threshold, the output of IC1b goes high, switching Q1 off and powering down most of the circuit. LED1's forward voltage drop (about 2V) allows Q1 to be turned off despite IC1b's output only being able to swing up to about Vcc - 2V. LED1 isn't intended as a power indicator; the high brightness LEDs do a fine job of that.

If jumper JP1 is left open, the low battery cutout is disabled since pin 6 of IC1b is pulled up to Vcc by the 120kΩ resistor. In this case, D2 prevents pin 6 from exceeding IC1b's maximum input voltage.

REG1 has a dropout voltage of about 1.7V so when Vcc is below 13.7V, the nominal 12V rail at its output is not regulated. All the components it powers run down to at least 9.8V, below which the low battery cutout normally activates.

With a 12V supply voltage, because of Q2's base-emitter voltage, Q4's maximum gate voltage is around 9V. That's still enough to turn it on fully (see the IRF540N datasheet).

Standby switch

When the standby switch (S1) is in the off position, it forces the low battery cut-out to operate by connecting pin 6 of IC1b to ground.

In this condition, 1.5-2mA is drawn from the supply. The advantage over switching the input supply directly is improved reliability. When the supply connection is made, there is a current inrush which can stress the switch and the power supply. Using the standby switch avoids this.

The standby switch has a 3-pin header to select which position (up or down) is off, depending on how the unit is mounted.

Circuit protection

The PC board is fitted with a 4A fuse (F1) to protect against circuit faults, while Mosfet Q5 provides protection against reverse supply polarity. This Mosfet acts like a diode but has a much lower forward voltage, thereby improving efficiency.

If the supply polarity is correct, Q5's gate is pulled up via a 100kΩ resistor. This switches Q5 on and completes the circuit to ground. However, if the supply polarity is reversed, the gate is instead pulled low, switching Q5 off and preventing current flow. Zener diode ZD2 protects Q5 from damage by limiting its gate voltage to +15V.

The unit can operate from supply voltages up to at least +30V (32V absolute maximum), while the reverse polarity protection circuit works for voltages down to -55V. Any voltage spikes higher than this (eg, due to load dumps) cause transient voltage suppressor TVS1 (1.5KE36CA) to conduct, shunting current away from the circuit. In extreme cases, the fuse may blow.

Choosing Alternative Parts

The flywheel diode (D1) is specified as an STPS1545F. Other Schottky diodes in the TO-220AC (two lead) package can be used if they have a current rating of 7A or more and a reverse breakdown voltage of at least 30V. Diodes with a lower reverse breakdown voltage are better because generally, the higher the reverse breakdown voltage, the higher the forward voltage.

It's also possible to use two Mosfets of the same type for Q4 & Q5 (either IRF540N or IRF1405) but doing so will reduce efficiency. If they are both IRF540Ns, the dropout voltage will increase.

The inductor can be either a 47μH 3A high-frequency toroid from Altronics (Cat. No L6517) or a 100μH 3A ferrite choke from Jaycar (Cat. LF1272). The 100μH inductor provides smoother current regulation but this makes no real difference when driving LEDs. Altronics also has a 3A 100μH inductor but it has a higher DC resistance than either of the specified parts, so it is not ideal. A 5A inductor could also possibly be used but will be a tight fit in the case.

Finally, although we have specified a bidirectional TVS, a unidirectional TVS can be used instead (eg, Altronics Z0127). However, if this part is used, the fuse will blow if the supply polarity is reversed.

Construction

All the parts mount on a single-sided PC board coded 16102111 and measuring 118 x 74mm. Begin by examining the copper side for defects such as hairline cracks or under-etched areas. It's also a good idea to test fit the larger components (eg, the switch, inductor, 5W resistor, terminal blocks, Mosfets etc) to check that the hole sizes are correct.

The specified case has corner pillars so if your board does not already have corner cut-outs, now is the time to cut and file them to shape.

Now refer to Fig.9 which shows the board assembly. Fit the three wire links first, followed by all the 0.25W resistors. Table 1 shows the resistor colour codes but you should also check each one on a digital multimeter before it is installed.

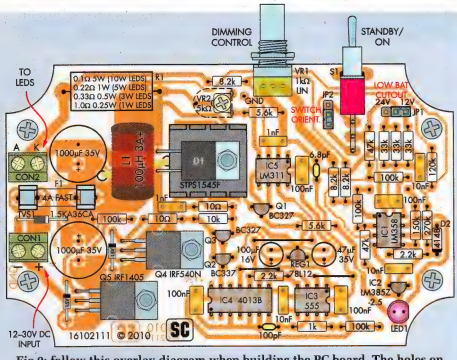
The 1N4148 diode (D1) and the two 15V zener diodes (ZD1 & ZD2) are next. These devices are polarised so orientate them as shown on the layout diagram. That done, install the transient voltage suppressor (TVS1).

If TVS1 has a stripe, then line it up as shown on the layout; otherwise it can go in either way. The specified part (1.5KE36CA) is quite large and must be mounted about 3mm above the PC board, so that it fits between the fuseholder and terminal block. Check that these parts will fit before soldering and trimming its leads.

Next, install the four DIP ICs. These can either be soldered direct to the board or you can use sockets if you prefer. Don't get the three 8-pin ICs mixed up; they are all different so check Fig.9 carefully when installing them. Make sure that each IC is correctly orientated and note that the 14-pin IC (IC4) faces in the opposite direction to IC3 & IC5.

The MKT and ceramic capacitors are next on the list (they can go in either way around). After that, fit the three small-signal transistors in the plastic TO-92 packages followed by REG1 and IC2. If necessary, use small pliers to crank their leads out and then back down parallel again so that they fit their mounting holes.

Check the markings on these devices


DIMMING CONTROL
STANDBY/ ON
TO LEDS
0.1Ω 3W (10W LEDS)
0.22Ω 1W (5W LEDS)
0.33Ω 0.5W (3W LEDS)
1.0Ω 0.25W (1W LEDS)
VR2 5kΩ
8.2k
5.6k
VR1 1kΩ LIN
SWITCH ORIENT
JP2
LOW BAT CUTOUT
24V
12V
JP1
1000µF 35V
L1 100µH 3A
D1
STPS1545F
IC5 LM311
4.8µF
100nF
1nF
8.2k
8.2k
100k
10nF
100nF
120k
100k
100k
100

ing soldered, otherwise they won't fit in the case.

The board assembly can now be completed by mounting the switch and potentiometer VR1. As before, make sure these parts are properly seated against the board before soldering their pins.

Finally, if you are going to install the unit in a moving vehicle (car, boat, caravan, etc), it is a good idea to additionally secure some of the larger parts using neutral-cure silicone sealant. These parts include all the electrolytic capacitors, the inductor, the pot and the switch. If this is not done, vibration may cause the leads to eventually crack.

Mounting the LEDs

The method we used for heatsinking the LEDs is not very practical for a typical installation. If the LEDs are to be mounted on the underside of a horizontal surface (shelf, cupboards, etc), one possibility is to mount them on a large, rectangular aluminium sheet. This sheet will act as the heatsink while being slim enough so that it is not normally visible. The supply wiring could pass through holes drilled in the sheet, with plastic insulation preventing accidental shorting of the supply terminals.

Alternatively, the LEDs could be mounted individually on separate heatsinks. Computer CPU heatsinks could be used, as the integrated fan will assist cooling and the fan can be run from the same 12V supply that's used to power the LEDs. We chose to avoid fans as the LEDs will almost certainly outlive the fan bearings.

This view shows the fully-assembled PC board. Take care with component placement and orientation and note that IC3 (555) & IC4 (4013B) face in opposite directions.

Mounting the LEDs properly is important. The first job is to solder them to an aluminium substrate circuit board. To do this, spread some thermal transfer compound on the metal underside of the LED, then place it on top of the board and solder the four pins. The board does a good job of drawing heat away from the pads, so you'll need a hot soldering iron to do this properly.

Be sure to solder the LEDs onto their substrate boards with the correct orientation. If you look closely at

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
1nF	0.001µF	1n	102
100pF	NA	100p	101
6.8pF	NA	6p8	6.8

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	270kΩ	red violet yellow brown	red violet black orange brown
❑	1	150kΩ	brown green yellow brown	brown green black orange brown
❑	1	120kΩ	brown red yellow brown	brown red black orange brown
❑	5	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	3	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	3	8.2kΩ	grey red red brown	grey red black brown brown
❑	2	5.6kΩ	green blue red brown	green blue black brown brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	2	22Ω	red red black brown	red red black gold brown
❑	1	1Ω	brown black gold brown	brown black black silver brown
❑	1	0.33Ω	orange orange silver brown	black orange orange silver brown
❑	1	0.22Ω	red red silver brown	black red red silver brown
❑	1	0.1Ω 5W	not applicable	not applicable

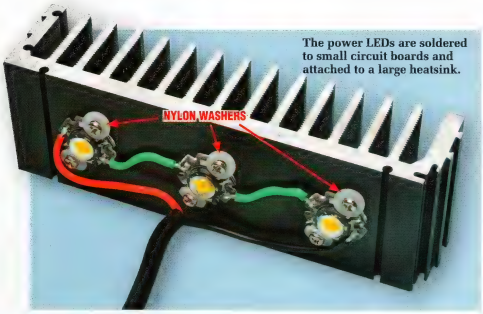


Fig.10: these full-size panel labels can be copied and used as drilling templates for the front and rear panels of the case. Use whichever pair is appropriate for your installation, so that the labels are the right way up when the box is installed.

the boards, you will see "+' and "-" signs adjacent to the pads, signifying the anode and cathode connections respectively. The cathode side of each LED is indicated by a tiny black dot on one of the leads (you will need a magnifying glass to see this).

Note that the two leads at each end are electrically connected, so it doesn't matter if they are bridged with solder when the LEDs are being mounted on the substrate boards.

Next, drill and tap the heatsink to accept the mounting screws. That done, solder the power leads to the LEDs, then spread thermal grease on the underside of each aluminium circuit board and screw it down firmly onto the heatsink. **Note that you must fit Nylon washers under the screw heads, to avoid shorts to the heatsink.**

Once they are all in position, their leads can be connected to the driver circuit. Make sure that these leads are securely anchored, so that they cannot come adrift and cause damage.

DO NOT under any circumstances run the LEDs without a heatsink. If you do, they can quickly overheat and fail.

Test & calibration

The completed PC board can now be tested and calibrated. Here's the step-by-step procedure:

(1) Install the 4A fast-blow fuse and turn both VR1 and VR2 fully anti-clockwise.

(2) If you have an adjustable DC supply, then test the low battery cut-out feature first. To do this, leave the power LEDs disconnected and set the supply to 11V. If the supply has a current limit feature, set it to 100mA or less and apply power to the board. LED1 should remain off and the current consumption should be below 2mA.

(3) Turn the voltage up to above 12V and check that LED1 turns on. The current consumption should increase to around 12mA. If either condition is not met, switch off and check for mistakes (eg, reversed or swapped components).

(4) To calibrate the unit, first determine the rated current for the LEDs you are using. You will need a 0.1-0.47Ω 5W resistor. If you are building the unit from a kit, you should have a spare resistor that will do the job.

(5) Connect the resistor in series with a digital multimeter (DMM) set to read amps (on its 5A or 10A range). Switch off and connect this arrangement between the power LED terminals on the PC board, ie, to CON2.

(6) Set trimpot VR2 to its mid-point and turn potentiometer VR1 fully anti-clockwise. Leave JP1 and JP2 open (ie, no shorting blocks installed).

(7) Connect a high-current 12V-24V supply, switch on and check that the current reading on the DMM is close

to zero. The supply current should be around 12mA.

(8) Slowly turn VR1 clockwise and check that the current through the test resistor eventually starts to rise. Turn VR1 fully clockwise and adjust VR2 for the correct current flow.

Note that the LED driver may produce a whine during this step as it delivers a much lower voltage than normal. It should go away when the LEDs are attached.

(9) Switch off and connect the LEDs in place of the test resistor. Make sure the LEDs are not pointing at your eyes, turn VR1 fully anticlockwise and re-apply power. Slowly turn VR1 up and check that the LEDs light and that their brightness is adjustable. Trim VR2 for the correct maximum current.

(10) Switch off and install a shorting block on JP1 to suit your installation (either 12V or 24V). If you are running the LED driver from a mains-powered supply you can leave it out but it is better to use the 12V setting, to reduce the inrush current when power is first applied.

Preparing the case

The PC board has been designed to fit inside an Altronics H0121 flange-mount plastic case. All you have to do is drill the necessary holes in the front and rear panels, fit the labels, mount the PC board on the integral stand-offs and connect the cables.

Fig.10 shows the front and rear panel labels which can be copied and used as drilling templates. Alternatively, you can download them as PDF files from the SILICON CHIP website and print them out.

Use a small pilot drill to start each hole, then carefully enlarge it to size using a tapered reamer. You need to drill two holes in the front panel to accept to switch and pot shafts and another two in the rear panel to accept cable glands.

Once these holes have been drilled, the labels can be laminated and affixed in position using a smear of silicone sealant. Alternatively, you can print the labels out back-to-front on clear film (make sure you printer can handle it) and silicone them into place. Printing them out back-to-front means that the labels are must be mounted with the ink towards the panel, so that this side is protected

Once the labels are in place, wait for the silicone to cure, then cut out the holes using a sharp hobby knife.

The completed unit minus the leads. It can be mounted with the case flanges either up or down, while power can come from any 12-30V 3A DC supply.

The PC board assembly can now be installed. First, slide a spring washer over the potentiometer shaft (or use two or three flat washers), then insert the board into the case, angled so that the pot and switch shafts go through their respective holes first. You may have to flex the box slightly to get the board in but if that fails, enlarge the pot and switch holes slightly.

Once the board is in place, secure it to the integral case standoffs using the supplied self-tapping screws. That done, fit the potentiometer nut – there won't be much exposed thread so use small pliers to push it down and turn it until it catches the thread. Do it up firmly, then check that the shaft is perpendicular to the edge of the case. If not, you will need to remove the board and add another washer.

Because the cable gland nuts are large, there won't be enough room for them between the PC board and the lid. To solve this, secure each nut in a vice between two scrap pieces of wood and file down the protruding ring on one side that so it is flush with the hexagonal surface. Do the same to the opposite side of each nut, then install the cable glands with the two filed edges against the PC board and facing up.

You will also need to cut and file away two notches in the rim around the edges of the lid so that it clears the nuts. This can be done using side-cutters and a flat file.

It's now just a matter of passing the power supply and LED cables through the glands, stripping the ends and attaching them to the screw terminal blocks. The glands can then be tightened to secure the cables to the case.

All that remains now is to install the switch orientation jumper JP2. To do this, fit the jumper shunt to one pair of pins on JP2 and apply power. Toggle the Standby switch and if its action is the opposite of what you require, move the shorting block to the other end of JP2.

That's it, the assembly is complete and you can now attach the lid and operate the unit. **Just remember our warning about not looking at the LEDs when they are at full brightness, or even approaching full brightness for that matter.** SC

PRODUCT SHOWCASE

element14 has the latest development kits from Microchip

element14, formally known as Farnell, has added development kits from Microchip to its inventory.

The PIC24FJ256DA210 Microchip Development Kit is a low cost, yet highly flexible platform that allows design engineers to evaluate the features and performance of the series with integrated graphics, USB and mTouch.

The mTouch series allows electronic design engineers to analyse and adjust their designs' touch sensing functions. The mTouch AR1000, which features an AR1000 development board and PICkit Serial Analyser, is another easy-to-operate and affordable tool for designers who intend to start on AR1000 resistive touch screen controllers. For design engineers who require the ability to easily adjust critical parameters in their design, they will now have at their disposal the mTouch Projected Capacitive Development Kit using the integrated Graphical User Interface (GUI) tool. Finally, the enhanced mTouch Capacitive Touch Evaluation Kit's Diagnostic Tool allows users to analyse application-critical information in real-time as it relates to touch sensor behaviour.

The last of the latest additions is the Multimedia Expansion Board, which provides design engineers with a highly adaptive and comprehensive solution for the development of high impact User Interfaces. Electronic design engineers can easily utilise this kit to connect to any PIC32 Starter Kit and from there develop, program and debug their designs in a hassle-free manner.

Contact:
element14
72 Ferndell St, Chester Hill NSW 2162
Tel: 1300 361 005 **Fax:** 1300 361 225
Website (Aus): http://au.element14.com
(NZ): http://nz.element14.com

Ocean Controls "FieldLogger"

The FieldLogger is a feature-packed data logger at an affordable price. It has eight configurable analog inputs that can read thermocouples, Pt100, Pt1000, voltage and 4-20mA current signals. It also has two relay outputs and eight digital ports individually configurable as inputs or outputs. A 24V DC output is available for powering up to eight 4-20mA transmitters.

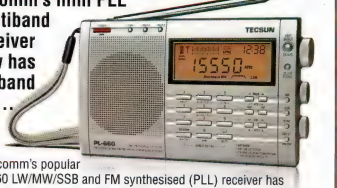
Up to 128 mathematical channels can be used to perform operations on the measured values. Up to 32 alarm events can be detected, allowing output activations, emails and SNMP traps sending.

Its RS485 interface can operate as a Modbus RTU master or slave. As a master, it can read and log up to 64 readings from external Modbus slaves. It has a 10/100 Mbps Ethernet interface that allows for access through a browser (HTTP), FTP (client and server), email sending (SMTP), SNMP and Modbus TCP.

FieldLogger has one USB interface to be connected to a computer (for configuration, monitoring and data download) and another USB port for plugging a flash driver for data retrieval. The 512k logging basic memory is used to store data and it can be greatly expanded with an SD card. A colour HMI can be attached or remotely installed for local indication or configuration. A user friendly software program can access the FieldLogger by Ethernet, USB or RS485.

Contact:
Ocean Controls
PO Box 2191, Seaford BC, VIC 3198
Tel: (03) 9782 5882
Website: www.oceancontrols.com.au

Avcomm's mini PLL multiband receiver now has air band too...



Avcomm's popular PL-660 LW/MW/SSB and FM synthesised (PLL) receiver has undergone a facelift and now includes the 118-137MHz aircraft band, without losing any of its existing extensive capabilities.

Compared to lesser-performing receivers of yesterday it is positively tiny (at just 187 x 114 x 43mm and only 470g). This new version is certain to be popular amongst the many aircraft band enthusiasts as well as general shortwave and broadcast band (AM and FM) listeners. While it has a built-in antenna for AM/LW reception, provision is made for an external aerial for shortwave and FM.

You can tune manually, by direct keypad frequency entry or use the PL-660s auto tuning functions.

It's powered by four "AA" cells or an external 6V DC plugpack. With SSB reception, nothing is missed on the short waves and its 2000 memory presets (automatic or manual storing) means there'll be no problem finding that elusive station again.

Contact:
Av-Comm
PO Box 225, Brookvale NSW 2100
Tel: (02) 9939 4377
Website: www.avcomm.com.au

VPO oscilloscopes set to replace DSO?

The new GW GDS-3000 VPO (Visual Persistence Oscilloscope) signal processing technology allows it to display waveforms with various gray scales based on the occurrence frequencies, comparable to the traditional analog oscilloscope display.

The GDS-3000 displays 3-dimension waveform data, including amplitude, time and intensity, for each waveform spot, providing more useful signal information than a normal digital storage oscilloscope can do. The high-speed FPGA parallel data processing enables the signal analysis of rapid events such as video, jitter, glitch and runt, as well as significantly increased data processing speed and therefore increased waveform update rate.

GW's GDS-3000 series include other never-before-seen features that will re-define user expectations in the affordable oscilloscope market segment. The 203.2mm screen dwarfs traditional 140mm screens, the high SVGA 800 x 600 resolution exceeds traditional VGA 340 x 240 DSO resolution by several orders of magnitude and the practical SVGA video output port allows the transfer of DSO screen image to an external projector or monitor for remote monitoring or big screen observation – ideal for education and commercial group presentations.

Contact:
Emona Instruments
PO Box 15 Camperdown NSW 1450
Tel: (02) 9519 3933 **Fax:** (02) 9550 1378
Website: www.emona.com.au

New Cree XM-L LEDs shatter industry performance standards

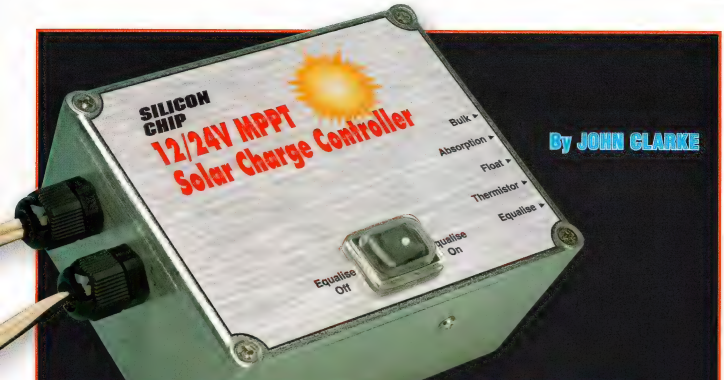
Elsewhere in this issue we feature "The Dazzler" – a driver for ultrabright (10W) LEDs which, frankly, are so bright they're, well, dazzling!

Stop the presses! LED manufacturer Cree has just announced the commercial availability of the industry's brightest, highest-performance lighting-class LEDs: their Single-Die XLamp XM-L LEDs, which deliver a staggering 1000 Lumens at 100 Lumens per Watt. With breakthrough light output and efficacy, Cree XLamp XM-L LEDs are designed for very-high-lumen applications, such as high-bay or roadway lighting.

A LED with this level of light output and this level of efficacy could enable applications not even thought of yet.

Setting a new standard for LED performance, the cool white (6500°K) XLamp XM-L LEDs deliver 1000 lumens with 100 lumens per watt efficacy at 3A. In a compact 5-mm x 5-mm footprint, XM-L LEDs offer the unique combination of very high efficacy at very high drive currents, delivering light output and efficacy of 160 lumens per watt at 350 mA and up to 315 lumens and 150 lumens per watt at 700 mA, providing a 20% efficiency gain from the Cree current industry-leading XLamp XP-G LEDs. *sc*

Contact:
Cutter Electronics Pty Ltd
Unit 12, 137-145 Rooks Rd, Vermont, Vic 3131
Tel: (03) 9873 5088 **Fax:** (03) 9873 5099
Website: www.cutter.com.au



By JOHN CLARKE

12/24V 3-Stage MPPT Solar Charge Controller

Are you building the ultrasonic anti-fouling unit for your boat? You will need a solar panel and a charge controller to keep the batteries topped up. Or are you thinking of a large solar panel for your caravan or 4-wheel drive? Again, you will need a solar charge controller. This is the one to build.

THIS CHARGE CONTROLLER is suitable for 12V panels up to 120W and 24V panels up to 240W. It incorporates Maximum Power Point Tracking (MPPT) and 3-stage battery charging. It works with any 12V panel from 40W up to 120W (3.3-10A) and can also be used with 24V panels in the 80W to 240W range, in conjunction with a 24V battery.

Wouldn't it be nice if you could just wire a solar panel (or panels) to a battery or two and leave it at that? Unfortunately, for all but the smallest panels, this is a very bad idea. The battery will be overcharged on sunny days and on cloudy days the battery may not charge at all, even though the panel is capable of harvesting energy. So there is no choice – you need a charge controller.

This Charge Controller is suitable for charging Flooded Lead Acid, Gel-Cell (Sealed Lead Acid or SLA) and AGM (Absorbed Glass Mat) type batteries. Ideally, any battery used in a solar system should be a "deep discharge" type. Car batteries are not deep discharge types and are not suitable.

Ultrasonic anti-fouling for boats

We have already mentioned the Ultrasonic Anti-fouling unit for boats (SILICON CHIP, September & November 2010). This must run continuously to protect the boat hull from marine growth and for those without shore power, a solar panel and charge controller is the only solution. For this application we recommend, at minimum, a 12V 40W panel with a 12V 12Ah SLA battery.

For continuous anti-fouling, the circuit draws an average of about 200mA. Over a 24-hour period this amounts to 4.8Ah or 60Wh per day from the 12V battery. This means that if a 40W panel generates full power for 1.5 hours or longer each day, this is enough for the anti-fouling unit to operate. However, if you are also concerned about auto-

matic operation of bilge pumps etc, a 40W panel would be a good choice. The reason we have specified a larger panel and battery than strictly necessary is twofold.

First, for a boat installation, you cannot orient the panel for best efficiency. If you are on a swing mooring, the boat's heading will constantly change according to wind direction and even if it didn't, you would still install the panel to result in minimum windage and this means that it must be installed horizontally. The same comment generally applies to a caravan installation. Second, you need a bigger panel to cope with sustained periods of bad weather when there is little sun.

In Australia, we receive a yearly average of five peak sun hours per day. Seasonal monthly breakdowns are available at **http://www.yourhome.gov.au/technical/fs67.html#siting**

MPPT & charge optimisation

Given that the solar panel is mounted horizontally, it is most important to collect as much energy as possible from it and this is where the Charge Controller's MPPT (Maximum Power Point Tracking) comes in.

As shown in Fig.1, for a typical solar panel exposed to full sunlight, the output ranges from maximum current when the output is shorted (Isc) to maximum voltage when the output is open circuit (Voc). For a typical 120W 12V panel, Isc is 7.14A and Voc is 21.8V. But the maximum power from a 120W panel is at 6.74A and 17.8V which is hardly a suitable match for a lead-acid battery.

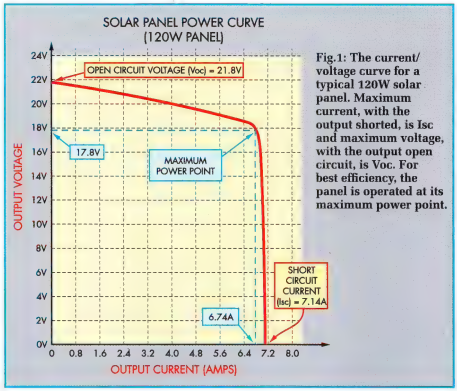


Fig.1: The current/voltage curve for a typical 120W solar panel. Maximum current, with the output shorted, is Isc and maximum voltage, with the output open circuit, is Voc. For best efficiency, the panel is operated at its maximum power point.

If we were to connect that 120W solar panel directly to the battery, the charge current would be about 7.1A at 12V (85.2W), 7.05A at 13V (91.7W) and 7A at 14.4V (101W), ie, much less than the 120W available from the solar panel at 17.8V.

By contrast, MPPT keeps the solar panel current and voltage at the maximum power point while charging the battery, even though the battery voltage is lower than the solar panel voltage.

This is achieved by an intelligent switchmode step-down voltage converter. To see how this works, refer to the block diagram of Fig.2 below. Current from the solar panel flows through diode D1 and Mosfet Q1. When Q1 is

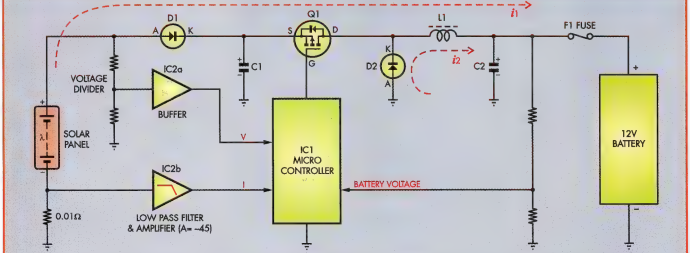
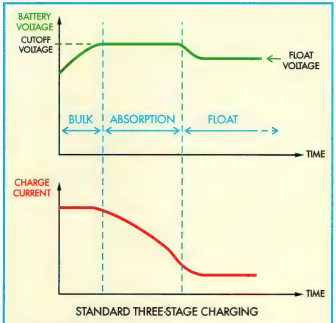
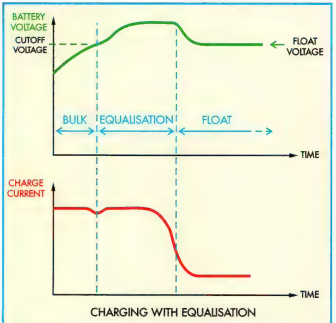


Fig.2: this block diagram shows how the microcontroller (IC1) monitors the battery and panel voltages and the current. It also shows how the switchmode step-down circuit for battery charging is arranged. When Q1 is on, current (i1) flows through inductor L1 and into capacitor C2 and the battery. When Q1 switches off, the stored energy in L1 is fed to the battery via diode D2 (current path i2).



STANDARD THREE-STAGE CHARGING

Fig.3: the three standard battery charging stages. First is the initial bulk charge. Once the battery reaches the cut-off voltage, the absorption stage takes over to fully charge it. Finally, the float stage maintains its charge.



CHARGING WITH EQUALISATION

Fig.4: the charging cycle with equalisation enabled. Instead of the absorption stage, the battery voltage is allowed to rise by 10% over the cut-off voltage to cause gassing within the cells. This charges the cells equally.

on, current (i1) flows through inductor L1 into capacitor C2 and the battery. This stores energy in the inductor's magnetic field.

After a short period, Q1 is switched off and the stored energy in L1 is fed to the battery via diode D2 (current i2). The microcontroller (IC1) controls this switching with a pulse width modulated (PWM) 31.25kHz gate signal to Q1. The ratio of the on to off period (duty cycle) for Q1 is controlled so that the solar panel delivers its maximum power.

The solar panel is not required to supply the peak current into the inductor as this is drawn from the reservoir capacitor, C1. Both C1 & C2 are low ESR (effective series resistance) types, suited to operation at high frequency.

The voltage from the solar panel is monitored by op amp IC2a, while op amp IC2b measures the panel current via a 0.01Ω current sense resistor. IC2b has a gain of -45 and works as a low-pass filter. Both op amps feed their signals to IC1 which then calculates the correct duty cycle for Q1 to keep the panel at the maximum power point.

12V Ah Capacity	Maximum Charge Current (Typical)	Maximum Solar Panel Rating	Recommended Solar Panel Rating
40Ah SLA & AGM	12A	140W	120W
40Ah Lead Acid	10A	120W	120W
38Ah SLA & AGM	11A	130W	120W
38Ah Lead Acid	9.5A	110W	80W
26Ah SLA & AGM	7.8A	90W	80W
26Ah Lead Acid	6.5A	75W	65W
20Ah SLA & AGM	6A	75W	65W
20Ah Lead Acid	5A	60W	60W
18Ah SLA & AGM	5.4A	65W	65W
18Ah Lead Acid	4.5A	50W	40W
12Ah SLA & AGM	3.6A	40W	40W
12Ah Lead Acid	3A	36W	20W

Table 1: recommended solar panel power ratings for 12V lead-acid (flooded wet cell) batteries, gel-cell (sealed lead acid or SLA) batteries & absorbed glass mat (AGM) batteries.

3-stage charging

As well as controlling the MPPT, IC1 also manages the charging of the 12V (or 24V) lead-acid battery.

The battery is charged in three stages, as shown in Fig.3. Charging begins as soon as the battery voltage is below 12.45V (assuming the panel is generating power) and starts with the "bulk charge" stage. During this stage, maximum power is transferred from the solar panel to the battery until it reaches the cut-off voltage, which is 14.4V at 20°C.

After this, the charger switches to the "absorption" phase where the battery is maintained at the cut-off voltage for one hour, to ensure it is fully charged. Finally, the "float" stage maintains the battery at 13.5V at 20°C, to keep the battery topped up.

The cut-off voltage (for the bulk and absorption stages) and the float voltage are reduced when the ambient temperature is above 20°C, in accordance with battery manufacturers' charging specifications. For a typical 12V battery, this is 19mV/°C (or double that for a 24V battery). So

for a 12V battery at 30°C, the voltages are reduced by 190mV, to 14.21V and 13.31V respectively.

The circuit measures ambient temperature with a negative temperature coefficient (NTC) thermistor within the charger. The assumption is that its ambient temperature is similar to that of the battery as they are usually in close proximity. If necessary, the thermistor can be connected to the charger via a flying lead so that it can be closer to the battery for more accurate temperature measurement.

No charging occurs if the thermistor wires are shorted or if it is not connected. This is useful when the thermistor is off-board, where the wiring could be damaged. A LED "Thermistor" indicator flashes momentarily once every two seconds when the thermistor is open circuit and once a second when it is shorted.

In addition, the charging state is indicated by three LEDs, one each for the bulk, absorption and float stages.

A battery that has been discharged below 10.5V will be charged using short bursts of current until it reaches 10.5V, whereupon the bulk charge will begin. This initial charge state is indicated by a short flash of the bulk stage LED, once every four seconds.

Equalisation

In addition to the standard 3-stage charging there is an option for battery cell equalisation. When enabled, an equalisation stage runs instead of the absorption phase (after the bulk charge stage). Equalisation is a process that attempts to ensure that all the cells in the battery are equally charged. Its occasional use can extend battery life.

What happens is that, over time, the electrolyte within the battery becomes stratified, with the acid solution strength varying with depth in the battery. Generally the solution is weaker at the top of each cell and stronger toward the bottom.

In addition, because a 12V battery comprises six 2V cells in series, it is common for some cells to become fully charged before others reach full charge. This leaves some cells undercharged while other cells can be overcharged.

In essence, equalisation is deliberate over-charging to ensure that gassing occurs in all the cells. This allows the electrolyte in the cells to be stirred up and to reverse any stratification that may have occurred. It effectively means that all cells are over-charged to a degree, rather than just one or two.

Hence, during equalisation, the battery is over-charged by about 10% above the cut-off voltage. Fig.4 shows the charging cycle with an equalisation stage replacing the absorption phase.

Equalisation should not be done frequently, however. In practice, standard lead-acid (flooded) batteries can have their life extended by equalisation once a month, while AGM and SLA batteries should only be equalised a couple of times each year. It is best to check the manufacturer's recommendations for equalisation intervals.

Because equalisation should only be run occasionally, the 12/24V Solar Charge Controller does not normally run an equalisation cycle. When the equalisation switch is turned on, the equalisation LED will flash twice in acknowledgement. It must remain on for equalisation to occur the next time the battery is charged (ie, following the next bulk charge stage).

During the equalisation phase, the equalisation LED stays lit. This LED flashes momentarily every two seconds when equalisation is complete and will continue flashing while ever the equalisation switch is still on. Equalisation will not occur again until the switch is turned off and then on again.

As shown in the photos, the Solar Charge Controller is housed in a die-cast aluminium case. Cable glands are included to clamp the leads to the solar panel and to the battery. The five LEDs protrude from the side of the case, indicating the charging state and thermistor connection errors. The charging LEDs do not light if the solar panel is not delivering power to charge the battery.

Circuit details

The full circuit for the Solar Charge Controller is shown in Fig.5. It's based on a PIC16F88-I/P microcontroller, IC1. The micro's inputs monitor the solar panel voltage and current, battery

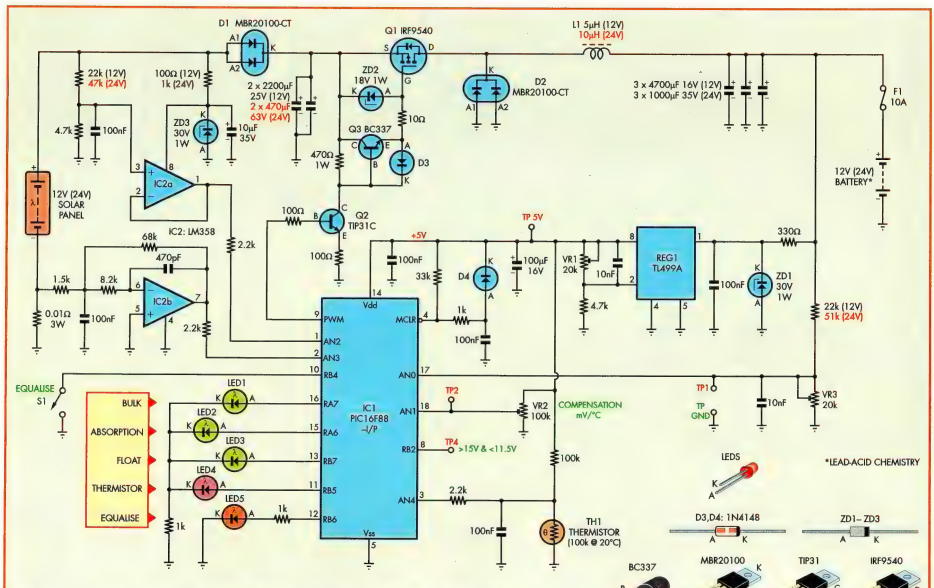
Features & Specifications

Features

Supports 40-120W 12V panels or 80-240W 24V panels
Microprocessor controlled
3-stage battery charging
MPPT (maximum power point tracking)
Automatic maximum power point detection
Charge indicator LEDs
Adjustable temperature compensation for charge voltage
Optional battery equalisation

Specifications

Battery standby current (all LEDs off):	3.6mA typical @ 12.6V
Charge start voltage	12.45V
Bulk charge cut off voltage (20°C)	14.4V
Absorption voltage (20°C)	14.4V
Float voltage (20°C)	13.5V
Equalisation voltage (20°C)	15.84V (14.4V + 10%)
Absorption/Equalisation time	1 hour
Temperature compensation	0-50mV/°C relative to 20°C (stops at 0°C)
Thermistor warning	open or short circuit
Low battery charge	below 10.5V charge duty cycle is 6.25%
Switching frequency	31.25kHz
Maximum power calibration	20ms every 20s
Charge termination	battery voltage >15V (except during equalisation) or panel voltage <12V
Equalisation	once each time switch is set
Voltage error output	high (5V) if voltage is below 11.5V or above 15V



SC 02/2011 12/24V THREE-STAGE MPPT SOLAR CHARGE CONTROLLER

Fig.5: the circuit for the 12/24V Solar Charge Controller is based on PIC16F88-I/P microcontroller IC1. This monitors the solar panel voltage and current, the battery voltage, temperature (via the NTC thermistor), the compensation trimpot position and the equalisation switch S1. The resulting PWM (pulse width modulation) output on pin 9 of IC1 then drives Mosfet Q1 via transistors Q2 & Q3, while several other outputs drive the charge indication LEDs.

voltage, temperature (using an NTC thermistor), compensation trimpot position and the equalisation switch (S1). IC1 then controls the drive to Mosfet Q1 and also the charge indication LEDs.

For charging, a switchmode step-down circuit is used as previously described. Mosfet Q1 is a P-channel type that switches on when its gate voltage is negative with respect to its source. The voltage at Q1's source (via the solar panel and diode D1) can range up to about 21.8V when there is no load on the solar panel.

Diodes D1 and D2 are each shown as two diodes connected in parallel. These diode pairs are within a single package and are designed to be connected in parallel, to increase the continuous current rating from 10A to almost 20A.

Sharing the current

Paralleling diodes does not normally result in current being shared equally and typically, one diode carries the majority of the current. This is because the forward voltages of the diodes are not normally well matched and so the diode with the lowest voltage drop will carry most of the current.

To make the situation worse, the diode carrying the most current will heat up more, in turn dropping its forward voltage and further increasing its share of the load. That's because the forward voltage decreases with increasing temperature.

By contrast, with a double diode, the two diodes are manufactured on the same silicon die and so each have the same characteristics, including matched forward voltages. They also operate at the same temperature because they are thermally connected. This ensures consistent and almost equal current sharing over temperature. This is confirmed by On Semiconductor's 20A rating for the two diodes in parallel, compared to a 10A rating for each diode.

The switching of Mosfet Q1 is controlled by NPN transistor Q2 which is driven by the PWM output (pin 9) of IC1 via a 100Ω resistor. Q2's emitter is connected to ground via another 100Ω resistor. With about 5V at Q2's base, the emitter is at about 4.3V and so there is 43mA through its collector.

When Q2 is on, Mosfet Q1's gate is pulled negative with respect to its source via diode D3 and the 10Ω resistor, thus switching Q1 on. Its gate is protected from voltages more than 18V below its source (which could damage it) by zener diode ZD2. The zener current is limited to 43mA by Q2's emitter resistor

While Q2 is on, NPN transistor Q3 is off as its base is one diode drop below its emitter, due to D3 being forward biased. Conversely, when IC1 switches Q2 off, Q3's base is pulled to Q1's source voltage via a 470Ω resistor. This switches Q3 on, pulling Q1's gate to its source and thus switching it off.

Battery monitoring

The battery voltage is monitored at IC1's AN0 input via a voltage divider comprising a 22kΩ resistor and 20kΩ trimpot (VR3). VR3 is adjusted so that the voltage appearing at AN0 is 0.3125 times the battery voltage. This divider is necessary since the maximum permissible voltage at the AN0 input is 5V. If the battery is at 15V, the voltage at AN0 will be 4.69V. The voltage at AN0 is converted to a digital value within IC1.

Ambient temperature is measured using thermistor TH1, which forms a voltage divider with a 100kΩ resistor across the 5V supply. IC1's AN4 input monitors the resulting voltage and software running within IC1 converts it to a value in degrees Celsius.

The temperature compensation setting is made using trimpot VR2, which is monitored by input AN1 of IC1. The voltage at this pin is converted to a mV/°C value, which can range from 0mV/°C with TP2 at 0V (VR2 fully anti-clockwise), up to 50mV/°C when TP2 is at 5V (VR2 fully clockwise).

Panel measurements

In order to conserve battery power, op amp IC2 is powered from the solar panel. Since we only need to measure the solar panel voltage and current when it is generating power, IC2 can be powered down the rest of the time.

IC2's supply voltage is regulated by 30V zener diode ZD3 and a 100Ω current limiting resistor, in case electromagnetic interference is picked up by the panel wiring. Diode D1 prevents the battery from powering IC2 via Q1's integral diode and L1. D1 also prevents the battery discharging into the solar panel when it is dark.

The solar panel voltage is monitored using a voltage divider consisting of 22kΩ and 4.7kΩ resistors. A 100nF capacitor filters any noise picked up in the panel leads. IC2a buffers the resulting voltage and applies it to input AN2 of IC1.

The voltage divider ratio allows for measurements of up to 28V from a 12V solar panel, at which point the voltage

WARNING!

When charging with the equalisation cycle, the battery will produce hydrogen gas which is explosive. **For this reason, make sure that the battery is located in a well-ventilated area during charging.**

Additionally, if equalisation is used, the battery voltage will rise above 15V and this could damage any equipment connected to it. If there is any risk of damage to such equipment, it should be disconnected during equalisation.

A test point (***TP>15V & <11.5V***) is available on the PC board and this goes to +5V when the battery is above 15V and during the equalisation. This output could be used to automatically disconnect equipment from the battery when the voltage goes above 15V.

A suitable circuit for doing this is the DC Relay Switch published in Silicon Chip, November 2006. The NC (normally closed) relay contact can be used to power the equipment when the battery is below 15V. The relay is energised to open the NC contacts above 15V.

This ***TP>15V & <11.5V*** output also goes to +5V when the battery voltage drops below 11.5V. It only returns to 0V when the battery voltage subsequently rises above 12V. This output can be used to disconnect equipment when the battery voltage is low, to prevent over-discharge.

A latching relay switch would be more effective for this application since the relay only draws power when switching. We plan to publish a suitable latching relay switch in a future issue of Silicon Chip.

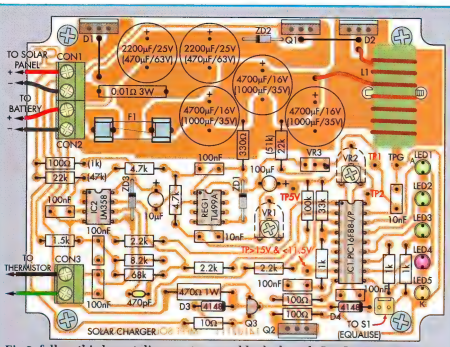


Fig.6: follow this layout diagram to assemble the board. Q1, Q2, D1 & D2 are mounted vertically and are bolted to the side of the case for heatsinking, while the leads for the LEDs are bent at 90° so that they go through holes in the side of the case. L1 is held in position with a cable tie.

This is the view inside the fully-completed unit. You will need to install an extra cable gland if you intend mounting the thermistor next to the battery.

at AN2 is almost 5V. Should a higher voltage be experienced, the 2.2kΩ resistor limits the current through AN2's internal clamp diode.

Current through the solar panel is measured by monitoring the voltage developed across a 0.01Ω resistor. With 7A flowing through the panel, the junction of the panel and this resistor will be at -70mV with respect to ground (ie, -10mV per amp).

This is inverted, filtered and amplified by IC2b. Below 1kHz the gain is -45, so IC2b's output is about 0.45V per amp of current flowing through the solar panel. This voltage is applied to the AN3 input of IC1 via a 2.2kΩ current limiting resistor.

Note that the precision of the voltage and current measurements made by IC1 is not critical. Periodically (every 20 seconds or so), it sweeps Q1's duty cycle in order to measure the current/voltage curve of the panel. It uses that to determine the maximum power point and then adjusts Q1's duty cycle to maintain maximum power.

The charge indicator LEDs are driven from five of IC1's outputs: RA7, RA6, RB7, RB5 & RB6 for the Bulk, Absorption, Float, Thermistor and Equalisation LEDs respectively. Note that four of these share a common 1kΩ limiting resistor as they are only driven one at a time. The Equalisation LED can light at any time so it requires its own limiting resistor.

Power supply

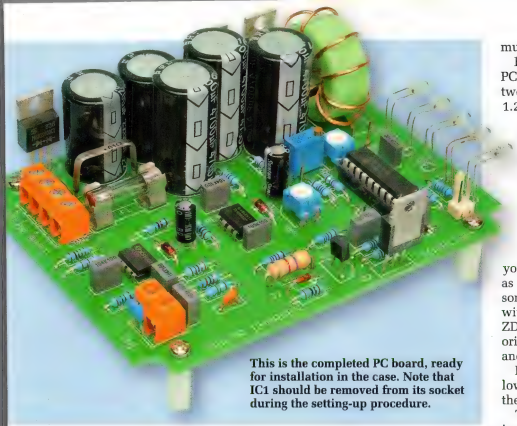
Power for IC1 is derived from the 12V battery via a TL499A regulator (REG1). This is a low quiescent current type that can run as a linear step-down regulator and as a switchmode step-up regulator. In this circuit, we are only using the linear function.

Its output is trimmed to 5V using VR1. This ensures that measurements taken by IC1's internal analog-to-digital converter (ADC) are accurate. REG1 is protected from excess voltage by a 30V zener diode and a 330Ω current limiting resistor.

The 5V supply is decoupled using a 100µF electrolytic capacitor and a 100nF capacitor at IC1's supply pin (pin 14). IC1 is reset when power is applied as its Master Clear Input (pin 4) is held low by a 100nF capacitor. This charges via the 33kΩ pull-up resistor, releasing the reset after a short period.

This reset arrangement is necessary because the 5V supply rise time is relatively slow due to charging of the three 4700µF capacitors across the 12V supply, which powers the 5V regulator. Diode D4 discharges the 100nF capacitor at power down so that it will provide the power-on reset immediately when power is reapplied. IC1 also includes a brown-out reset that operates if the supply voltage drops below 4V.

Protection against reverse polarity connection of both the 12V battery and solar panel is included. If the solar panel is connected with reverse polarity, IC2 is protected because zener diode ZD3 will be forward biased, clamping pin 8 at -0.6V. Diode D1 prevents reverse voltage being applied



This is the completed PC board, ready for installation in the case. Note that IC1 should be removed from its socket during the setting-up procedure.

to the remainder of the circuit.

Should the battery be connected back to front, diode D2 conducts via inductor L1 and fuse F1. As a result, the fuse will blow and break the connection.

Construction

The 12V/24V MPPT Solar Charge Controller is built on a PC board coded 14102111 and measuring 111 x 85mm. This is mounted in a diecast box measuring 119 x 94 x 57mm.

The PC board is designed to be mounted on 15mm tapped spacers. Make sure the board is shaped so it fits into the box. If not, the corners can be cut out and filed to shape until it clears the corner pillars.

Before starting the assembly, check the PC board carefully for possible defects (eg, breaks in the tracks or shorts between tracks and pads). Check also that the hole sizes are correct for each component to fit neatly. The screw terminal holes must be 1.25mm in diameter compared to the 0.9mm holes for the ICs, resistors and diodes. Larger holes again are required for the fuse clips, while the board mounting holes must be 3mm diameter.

Fig.6 shows the parts layout on the PC board. Assembly can begin with the two wire links. These are made from 1.25mm diameter enamelled copper wire. Bend each link so that it fits neatly into the holes provided on the PC board, then scrape off the enamel coating at each end using a sharp hobby knife or abrasive paper, so that it can be soldered in place.

Next, install the resistors, using the resistor colour code table as a guide. However, we also advise you to use a DMM to check each value as it is installed, as the colours can sometimes be hard to read. Follow this with diode D3 and zener diodes ZD1-ZD3, which must be mounted with the orientations shown. Leave diodes D1 and D2 out for the time being.

IC1's socket is next on the list, followed by REG1, IC2 & Q3. Check that the orientation is correct in each case.

Trimpots VR1 & VR2 can now be installed, followed by the 2-way and 4-way screw terminal blocks. Make sure that the latter are orientated with their openings towards the outside edge of the PC board. The 4-way terminal block is made using two 2-way blocks and these must be dovetailed

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
470pF	NA	470p	471

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	68kΩ	blue grey orange brown	blue grey black red brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	1	8.2kΩ	grey red red brown	grey red black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.5kΩ	brown green red brown	brown green black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	470Ω 1W	yellow violet brown brown	not applicable
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	3	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	0.01Ω	not applicable	not applicable

Parts List For Solar Charge Controller

1 PC board, code 14102111, 111 x 85mm
1 diecast aluminium case, 119 x 94 x 57mm
2 IP65 cable glands for 4-8mm diameter cable
3 2-way PC-mount screw terminal blocks, 5.08mm pin spacing (Jaycar HM-3130)
1 SPST mini rocker switch (S1)
1 waterproof switch cap (optional)
1 2-way PC-mount polarised locking pin header (2.54mm pitch)
1 2-way polarised header socket with 2.54mm pin spacing
2 M205 PC-mount fuse clips
1 M205 10A fuse (F1)
1 NTC thermistor, 100kΩ at 25°C (TH1)
1 DIP18 IC socket
1 iron-powdered toroidal core, 28 x 14 x 11mm
4 TO-220 mounting kits (insulating bushes and silicone insulating washers)
4 M3 x 15mm tapped Nylon spacers
4 M3 x 12mm countersink Nylon screws
4 M3 x 10mm machine screws
4 M3 x 6mm machine screws
4 M3 nuts
1 400mm-length of 1.25mm enamelled copper wire
1 50mm-length of medium-duty hookup wire
5 PC stakes
1 100mm cable tie
1 20kΩ horizontal-mount trimpot (VR1)
1 100kΩ horizontal-mount trimpot (VR2)
1 20kΩ multi-turn top adjust trimpot (VR3)

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1410211A.hex (IC1)
1 LM358 dual op amp (IC2)
1 TL499A regulator (REG1)
1 IRF9540 P-channel 100V 23A Mosfet (Q1)
1 TIP31C NPN transistor (Q2)
1 BC337 NPN transistor (Q3)
2 MBR20100CT 10A 100V double Schottky diodes (D1, D2)
2 1N4148 switching diode (D3, D4)
2 30V 1W zener diodes (ZD1, ZD3)
1 18V 1W zener diode (ZD2)
3 3mm green LEDs (LEDs1-3)
1 3mm red LED (LED4)
1 3mm orange LED (LED5)

Capacitors

3 4700µF low-ESR 16V PC electrolytic
2 2200µF low-ESR 25V PC electrolytic
1 100µF 16V PC electrolytic
1 10µF 35V PC electrolytic
6 100nF MKT polyester
2 10nF MKT polyester
1 470pF ceramic

Resistors (0.25W, 1%)

1 100kΩ	1 1.5kΩ
1 68kΩ	3 1kΩ
1 33kΩ	1 470Ω 1W
2 22kΩ	1 330Ω
1 8.2kΩ	3 100Ω
2 4.7kΩ	1 10Ω
3 2.2kΩ	

1 0.01Ω 3W resistor (Welwyn OAR3-R010FI) (Element14 Cat. 120 0365)

Parts For 24V Operation

3 1000µF low-ESR 35V PC electrolytic capacitors (instead of 3 x 4700µF 16V)
2 470µF low-ESR 63V PC electrolytic capacitors (instead of 2 x 2200µF 25V)
1 51kΩ 0.25W 1% resistor (instead of 22kΩ)
1 47kΩ 0.25W 1% resistor (instead of 22kΩ)
1 1kΩ 0.25W 1% resistor (instead of 100Ω)

together before installing them on the PC board.

The low-value capacitors can now go in, followed by the larger electrolytics. Be sure to orientate the electrolytics correctly.

The fuse clips are next. These must go in with their retaining tabs on the outside, otherwise you will not be able to fit the fuse later on. Once they are in, install the 0.01Ω 3W resistor, then fit Q1, Q2, D1 & D2 so that the mounting hole centre in each tab is 21mm above the PC board. In each case, the metal tab must go towards the outside edge of the board – see Fig.6.

Installing the LEDs & L1

The LEDs are mounted with their plastic bodies exactly 20mm above the PC board. This is done by pushing each LED down onto a 20mm cardboard spacer inserted between its leads as it is soldered into position. Take care with their orientation – they all face the same way, with the anodes (longer leads) towards L1. These LEDs are later bent over through 90°, to go through holes in the side of the case.

Inductor L1 is wound using seven turns of 1.25mm diameter enamelled copper wire on a powdered iron toroidal core. Space the turns evenly. The wire ends are then stripped of the enamel and terminated on the PC board as shown. A cable tie that passes through the centre if the toroid and adjacent holes on either side is then fitted, to secure it in position.

Finally, complete the board assembly by installing the polarised locking pin header (at bottom right).

Preparing the case

Holes are required in the case for the 15mm tapped spacers (to support the PC board), the two cable glands, the LEDs and for mounting Q1, Q2, D1 & D2 (the latter are attached to the case for heatsinking). In addition, you will need a cut-out in the lid to accept the equalisation switch (S1).

Start by placing the PC board inside the case and marking out the positions for the four mounting holes. These should then be drilled using a 3mm (or 1/8-inch) drill. Countersink them on the outside of the case.

That done, drill the holes for the cable glands. These are located at the end of the box above and adjacent to the terminal blocks. If you intend mounting the thermistor next to the battery, an extra cable gland will be required for its entry lead.

The next step is to drill the holes for the LEDs. These holes are positioned 20mm down from the top of the case and you can determine their horizontal locations by temporarily positioning the PC board in the case.

Drill these holes to 3mm, then fit the 15mm Nylon spacers to the case, secure the board in position and mark out the mounting holes for Q1, Q2, D1 & D2. Remove the board and drill these mounting holes to 3mm, then use

The PC board is mounted inside the case on four M3 x 15mm tapped Nylon spacers. Be sure to use a cable tie to secure the large toroidal inductor (L1), to prevent it moving and breaking its leads.

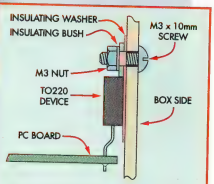


Fig.7: Q1, Q2, D1 and D2 must be electrically isolated from the case using silicone insulating washers and insulating bushes. After mounting each device, use your DMM (set to a high Ohms range) to check that the metal tab is indeed isolated from the case.

an oversize drill to remove any metal swarf so that the area around each hole is perfectly smooth.

This is necessary to prevent punch-though of the insulating washers when

The next step is to bend the LED leads at right-angles, exactly 12mm up from PC board. A 12mm wide cardboard spacer can be used to get this just right. That done, secure the PC board to the 15mm spacers using four M3 x 6mm screws, then secure the TO-220 devices to the sides of the case as shown in Fig.7.

Note that it is necessary to isolate each device tab from the case using an insulating washer and insulating bush. Once they have been installed, use a DMM (set to Ohms) to confirm that the metal tabs are indeed isolated from the metal case. If a low resistance reading is measured, check that the silicone washer for that particular TO-220 device not been punctured.

Using 24V Batteries & Solar Panels

The Solar Charge Controller can also be used with 24V batteries and 24V solar panels. However, this requires some component changes to the circuit and these are indicated on Fig.5. The changes are as follows:

(1) The 22kΩ resistor at pin 3 of IC2a is changed to 47kΩ, the 100Ω resistor feeding ZD3 is changed to 1kΩ and the 22kΩ resistor at the AN0 input of IC1 is changed to 51kΩ.

(2) The 2200µF 25V low-ESR capacitors are all changed to 470µF 63V low ESR types, while the 4700µF 16V low-ESR capacitors are changed to 1000µF 35V low-ESR types.

(3) The number of turns for L1 is increased from seven to 10.

Note that the dissipation in Q2 will rise to around 500mW but suitable heatsinking is already provided by the case.

Several set-up changes are also required:

(1) The voltage at TP1 (set by VR3) must now be the battery voltage x 0.15625 (instead of 0.3125).

(2) The voltage at TP2 for temperature compensation must be half that set for 12V operation. For example, for 38mV/°C compensation with a 24V battery, TP2 should read 1.9V (not 3.8V).

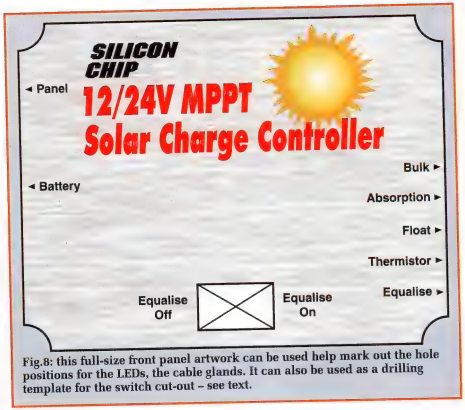


Fig.8: this full-size front panel artwork can be used help mark out the hole positions for the LEDs, the cable glands. It can also be used as a drilling template for the switch cut-out – see text.

The front-panel label (Fig.8) can now be used as cutting template for switch S1 which mounts on the case lid. This label can either be copied or downloaded in PDF format from the SILICON CHIP website and printed out.

To make the cut-out, secure the template using adhesive tape, then drill a series of small holes around the inside perimeter. It's then just a matter of knocking out the centre piece and filing to a smooth finish.

Once the hole has been made, laminate a second copy of the label and attach it to the lid using some silicone sealant. Wait 24 hours for the silicone to cure, then cut out the rectangular switch hole in the label using a sharp hobby knife.

Setting up

The step-by-step setting up procedure is as follows:

(1) Check that IC1 is OUT of its socket, then fit the fuse and apply 12V to the battery input terminals (leave S1 disconnected for the time being).

(2) Connect a DMM between TP5V and TP GND and adjust VR1 for a reading of 5.0V.

(3) Measure the voltage across the battery terminals and multiply this by 0.3125 using a calculator.

(4) Connect your DMM between TP1 and TP GND and adjust VR3 so that the DMM reads the calculated figure. For example, if the battery terminal voltage is 12.0V, TP1 should read 3.75V.

(5) Adjust VR2 so that TP2 reads the required temperature compensation value in mV/°C for your battery. This will be between 0V and 5V, representing 0-50mV/°C, ie, 1V = 10mV/°C.

You can find the recommended temperature compensation for your battery by looking up its specifications. Usually the compensation is specified on a graph showing its fully-charged voltage against temperature. This can be converted to a mV/°C figure by measuring its slope.

(6) Disconnect the 12V supply, wait for the 5V rail (at TP5V) to drop to 0V, then plug IC1 into its socket.

Installing TH1 & S1

Thermistor TH1 can either be secured directly to the 2-way terminal block on the PC board or located near the battery. In the latter case, you will have to run a figure-8 lead from the terminal block to the thermistor via an extra cable gland. This lead should be soldered to the thermistor and the solder joints insulated with tubing.

Switch S1 is connected to the PC board via the 2-way polarised header – see photo. After that, it's just a matter of connecting the panel and the battery.

Keep in mind that if the panel is made up from multiple solar cells, it is best to connect a diode across each cell which is reverse biased during normal operation. Otherwise, if one cell is in shade the whole panel will not generate any power. These diodes must be rated to withstand the short-circuit current of the panel.

Finally, if you are using the unit in a marine environment, the box should be waterproofed. Any exposed M3 screws should be marine grade stainless steel, while the spacers inside the case and the securing screws can be Nylon or stainless steel.

The cable glands provide waterproofing for the lead entries but the lid will need to be sealed with neutral-cure silicone sealant. Additionally, the LEDs will need to be sealed around their entry holes using silicone sealant. The external screws should also be waterproofed with silicone.

Switch S1 can be made waterproof by fitting a waterproof switch cover, as shown in the lead photo. SC

Cable Resistance Must Be Kept Low

When the Solar Charge Controller is used with a 120W panel, charging current to the battery can be as high as 10A. Hence, the cable resistance between the Charge Controller and the battery should be made as low as possible, otherwise voltage losses will affect the changeover from the bulk charge to the absorption stage of charging. This will reduce the overall charging efficacy.

To minimise these voltage losses, mount the charger close to the battery and use heavy duty cables. For a total cable length of less than one metre (ie, total wire length for the positive and negative wires), cables with a cross-sectional area of 1.29mm square (eg, 41 x 0.2mm) can be used. This will result in a voltage loss of about 100mV at 10A.

For longer wire lengths use heavier duty cable. For example, 8-gauge wire with 7 x 95/0.12mm wire with a cross sectional area of 7.5mm can be used up to 5.5m in total length. The specified Weidmuller screw terminal blocks (Jaycar HM-3130) are rated at 17.5A (IEC) and can accept wire diameters up to 2.5mm.

Car Video Event Recorder

Records video up to 5hrs for a 16GB SD Card (not included) to create a record of accidents or driver and vehicle performance. It's automatically activated by the built-in 3-axis G sensor that responds to a sudden change in wheel speed. It starts recording to an SD card and can also be triggered manually. Simply mounts onto the windscreen like a GPS unit. Ideal for fleet operators, taxis, hire cars or the everyday person who spends a lot of time on the road.

- 120° wide-angle camera with IR LEDs
- Supports SD cards
- Video resolution: 640 x 480 @ 30 fps
- Real time clock stamp
- Video output for external monitor
- Dimensions: 92(W) x 80(H)mm

QV-3798

$249.00

Back to School & Back to Work too!

Remote PC Control Over Ethernet Adaptor

Want to play games, browse the net or watch films on your TV when your computer is in another room? This adaptor allows all of the above over a simple ethernet connection. It features 2 x USB ports to connect a keyboard/mouse for remotely controlling your PC and 2 x 3.5mm sockets for audio and microphone input. Output is to DVI which may require an adaptor for connection to your flat panel TV.

- Supports Microsoft Windows XP, Vista and 7
- Dimensions: 120(L) x 57(W) x 21(H)mm

XC-4976

$149.00

Recommended accessories:
DVI to HDMI Cable PA-3644 $16.95
Wireless Trackball Keyboard XC-4941 $99.00

4 Channel Network DVR with 10" Monitor & Camera Package

This surveillance package offers exceptional value for money. It includes a H.264 DVR with built-in 10" LCD monitor and 320GB HDD, 2 indoor/outdoor CMOS 350TVL cameras with IR illumination for night viewing, 2 x 18m cables and power supplies. Everything you need in one box! Recording can be started manually, by programming or by triggered alarm conditions. The main feature is the Smart Phone support and the iPhone® app you can download from iTunes® to view live or recorded footage*. Monitoring may be done real-time on a VGA monitor, LAN or on an iPhone® or Smart Phone. The DVR functions can be controlled either by mouse or the IR remote control.

- DVR dimensions: 208(L) x 85(W) x 242(H)mm
- Camera Dimensions: 115(L) x 45(H)mm
- Additional camera sold separately: QC-3239 $59.95

*App is free for single use and may incur a charge for multi-user

QV-3030

$799.00

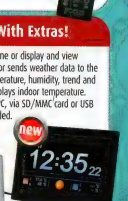
Home Theatre PC Remote Control

Simply plug in the USB dongle and away you go. All the mouse functions are controlled by a state-of-the-art fibre optics. It also includes Windows hot keys and all the TV functions as well.

- Compatible with Windows 2000, XP, Vista, 7
- Dimensions: 200(L) x 65(W) x 22(H)mm

XC-4939

$99.00



Weather Station With Extras!

Keep tabs on the weather and time or display and view cherished photos. A remote sensor sends weather data to the display unit which provides temperature, humidity, trend and forecast information and also displays indoor temperature. Photos can be loaded by a host PC, via SD/MMC card or USB flash drive. Mains plugpack included.

- 12/24 hour clock with alarm
- Time & date display with DST & time zone
- Weather & photo display
- Wall or desk mount
- Mains powered
- Dimensions: 200(W) x 150(H) x 30(D)mm

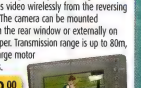
XC-0345

$159.00

Computer Cable Travel Kit

Contains over 900mm of pull to extend cable for several PC connections for those just out of range peripherals. Also comes with connectors and 4 way USB hub. See website for full specifications.

XM-5280



$24.95

Roll Up Keyboard USB POWERED

A flexible and virtually indestructible QWERTY keyboard with moisture-resistant silicone to take all kinds of punishment. The material of the keyboard creates a soundless typing experience and is ideal for industrial or wet areas such as factories, labs or workshops etc.

- USB powered
- Easy transportation
- Compatible with Windows 2000/XP/Mac
- Rolled up size: 80(W) x 135(H)

XC-5172 Due Early February

$19.95

2.4GHz Wireless Reversing Camera & LCD Monitor Kit

The LCD on this unit plugs straight into your car's cigarette lighter socket and receives video wirelessly from the reversing camera via 2.4GHz band. The camera can be mounted internally to view through the rear window or externally on the number plate or bumper. Transmission range is up to 80m, so it is suitable for very large motor homes, trucks or caravans.

- 3.5" LCD
- Power: 12VDC
- Range: 80m
- Dimensions: 110(W) x 76(H) x 21(W)mm

QM-3796

$199.00

2-Zone Alarm Kit

Simple two zone, two wire alarm for small to medium size premises. Included is one passive infrared sensor for large areas and a reed switch for one entry point such as a door or window. It also has the visible deterrent of an external siren box and additional sensors can be added if required. Everything you need to protect a small house or apartment.

Kit includes:
1 x 2-Zone control unit
1 x PIR sensor
1 x Reed switch
LA-5480

Spare PIR Sensor:
LA-5481 $24.95

$99.00

EASY TO USE & INSTALL

3-Step MPPT Solar Charge Controller

Charge controllers are essential for solar setups, although commercial units can run into several hundred dollars. Designed for use with 40W to 120W 12V solar panels and lead acid batteries, this solar charger provides 3-stage charging with the option of equalisation and with MPPT (Maximum Power Point Tracking). Operation is for 12V and the kit configured for this voltage, a 24V upgrade will be available in future. Kit includes PCB, all components and case.

Features

- Suitable for 40W to 120W 12V solar panels
- 3-step charging
- MPPT (maximum power point tracking) charging
- Charge indicator LEDs
- Temperature compensation for charge voltage
- Optional equalisation cycle
- Optional 24V 80W to 240W operation upgrade

KC-5500

$129.00

JAYCAR MIDLAND WA

NOW TRADING SUNDAY 11AM TO 4PM

www.jaycar.com.au

To order call 1800 022 888

Jaycar Electronics
Better, More Technical

Prices valid until 23/02/2011. Limited stock on sale items. No rainchecks. All Savings are based on Original RRP

Economy Nibbling Tool

Will cut any shape out of aluminium, plastic, copper and other unhardened metals up to 18 gauge. The tool is designed to fit in the palm of your hand for easy use, simply drill a 1/4" hole to start.
TH-1768 WAS $19.95

$14.95 SAVE $5.00

Audio Power Amplifier IC Module

Building a medium power audio amplifier has never been so easy. These versatile modules contain all of the amplifier's electronics and require only a simple power supply to get them up and running. The amplifiers feature low distortion, and are suitable for 4 or 8 ohm operation. Power supply and some external components required. Two models available:

- Power Required: +/-22V
- Power Output 8 Ohms: 20W
- Power Output 4 Ohms: 24W

ZL-3760 WAS $9.95

$4.95 SAVE $5.00

THATS 50% OFF

- Power Required: +/- 35V
- Power Output 8 Ohms: 50W
- Power Output 4 Ohms: 60W

ZL-3762 WAS $12.95

$6.95 SAVE $6.00

Double Sided Mounting Tape

For thousands of uses like mounting PCBs in your project to light duty mounting applications.

- Double sided
- 12mm wide

FROM $3.95 Per Roll

Two sizes available:

10m roll (Foam backed)	NM-2821 $4.95
30m roll	NM-2823 $3.95

PC Boards – Vero Type Strip

Alphanumeric grid, pre-drilled 0.9mm, 2.5mm spacing

- 95mm wide x 3 handy lengths

FROM $3.50

76mm	HP-9540 WAS $4.50	NOW $3.50	SAVE $1.00
125mm	HP-9542 WAS $7.95	NOW $5.95	SAVE $2.00
303mm	HP-9544 WAS $11.50	NOW $9.50	SAVE $2.00

32 Piece Precision Driver Set

High quality driver set with all those really small bits. Tactile handle with hardened hex shaft that extends from 140 to 210mm. Ideal for jewellery, model making or electronics.

- Slotted, Phillips, Pozidriv, Torx and hex
- Case included

TD-2106 WAS $17.95

$14.95 SAVE $3.00

See online for full set of contents

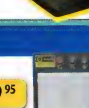
Solder Stand with Solder Reel Dispenser

Perfect for the workshop and keeps solder tidy and in its place. Holds reels up to 1kg.

$17.95

- Weight 620g
- Size 90(l) x 100(W) x 110(H)mm

TS-1504



Breadboards

- Mounted on a metal plate
- Rubber feet
- 1680 tie points
- 400 distribution holes
- 1280 terminal holes
- 3 banana terminals
- Board size: 130(W) x178(H)mm

PB-8816

$39.95

BUY BOTH FOR $35 SAVE $16.90

Breadboard Jumper Kit

This kit is specifically made for breadboards and consists of a single core sturdy wire which has been stripped on each end and bent at right angles.

- 5 packs each of 14 different lengths

PB-8850

$11.95

Wire Draw Fish Tape

The smart way to draw cable through wall cavities or conduit. 30m of rigid spring steel with a built-in cable clip on one end. No electrician or installer should be without one.

- Length: 30m
- Size: 305(Dia) x 38(H)mm

TH-1869

$29.95

Battery Powered 6W Soldering Iron

Ideal for on-site repairs and PCB work. Heats to soldering temperature in about 10 seconds. Requires 3 x AA batteries.

- Dimensions: 175(L) x 36(W) x 18(D)mm

TS-1535

$19.95

60W Lead-Free Soldering Station with LCD Panel

This excellent soldering station is particularly suited to lead-free soldering and is just as capable with ordinary leaded solder. The soldering pencil is fitted with a soft insulated rubber grip and has a silicon rubber sheathed power cable. Mains operated.

- Microprocessor controlled
- Temperature range 160°C to 480°C
- Set and actual temperature display

TS-1390

$179.00

Spare Tips also available:

0.4mm Conical	TS-1391	$12.95
1.0mm Conical	TS-1392	$12.95
2mm Chisel	TS-1393	$12.95
3mm Bevel	TS-1394	$12.95

Telescopic Magnetic Pickup Tool

Dropped the last bolt into the crankcase? No problem - with this handy tool, you can see where it is with the built-in LED torch and retrieve it with the magnetic tip. The torch comes on as soon as you extend it and it has a handy pocket clip so it doesn't get lost.

A MUST HAVE FOR EVERY TOOLBOX

- Picks up over 100g in weight
- Batteries included
- Extends to 870mm
- 170mm long (closed)

TH-1877

$17.95

4 Tray Tool/Storage Case

Each compartment has a 233 x 122 x 32mm 13 compartment storage box for small items with dividers that can be removed to accommodate larger things. All the hinges and catches are the durable pintle type and the top tray has a generous 265 x 160 x 65mm space for ancillary items.

- Dimensions: 270(W) x 260(H) x 150(D)mm

HB-6302

$16.95

For The Handy Man

7 Piece Screwdriver Set

new

High quality, bright red drivers you can find easily. Insulated right to the tip and rated to 1000V.

Drive sizes: Flat: 1.2 x 6.5 x 150mm, 1 x 5.5 x 125mm, 0.8 x 4 x 100mm, 0.6 x 3.5 x 75mm.
Phillips: #2 x 100mm, #1 x 80mm, #0 x 60mm. Includes storage box.

TD-2022

$24.95

100 Piece Driver Bit Set

This is an excellent driver bit set that contains just about every bit you could ever need. It has a magnetic holder, adaptors, Phillips bits, slotted bits, Torx, tamperproof, pin drive, and even a wing nut driver.

TD-2038

$19.95

188pc Rotary Tool Accessories Pack

At substantially lower cost than the hardware store brands and with 188 pieces, this kit will service every rotary tool bit you'll ever need. Everything is housed in a case so you can see exactly where all the bits belong. Sanding, grinding, cutting and polishing attachments. See website for full list of contents.

TD-2458

$19.95

9 Piece Folding Torx Key Set

Handy folding sets of Torx or Allen keys with sturdy anodised aluminium handles. The handles have M6, M10, E8 and E10 spanners built into them.

NEVER LOSE A BIT AGAIN

Torx Key Set: T5, T6, T7, T8, T9, T10, T15, T20, T25
TD-2170 WAS $7.95 NOW $5.95 SAVE $2.00

Ball Allen Key Set Metric: 1.5, 2, 2.5, 3, 4, 5, 6
TD-2172 WAS $7.95 NOW $5.95 SAVE $2.00

Ball Allen Key Set Imperial: 1/16", 5/64", 3/32", 1/8", 5/32", 3/16", 7/32"
TD-2174 WAS $7.95 NOW $5.95 SAVE $2.00

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

7" Screen 100MHz Dual Channel DSO

Enhanced performance, professional level test instrument for the technician, design engineer or development laboratory. Full 100MHz bandwidth to keep up with the current digital chip technology, plus a host of features that make it a cost-effective addition or upgrade to your current test equipment. Big 7" colour screen, smaller, lighter more portable and with a host of extra features, and it even includes a carry bag. Packed with features - see online for more details.

- Channels: 2
- Input impedance: 1Mohm
- Bandwidth: 100MHz
- Sampling rate: 1GSa/sec (per channel)
- Input coupling: AC, DC, GND
- Max input voltage: 400V DC+AC P-P, Cat II
- Accessories: 2 x 10:1 probes, EasyScope 3.0 software, USB cable
- Weight: 2.4kg
- Dimensions: 340(W) x 150(H) x 110(D)mm
- Display: Type: Colour TFT, LCD 178mm,
- Resolution: 480 x 234 pixels

QC-1934

$1149.00

400A AC/DC Clampmeter

Easy one-hand operation makes this meter perfect for the working installer or tradesman. This is a quality, intermediate-level clampmeter with current ranges up to 400 amps AC & DC.

- Cat III 600V, Autoranging
- Diode test
- Audible continuity
- Jaw opening 30mm
- Temperature probe
- Carrying case
- Dimensions: 198(H) x 66(W) x 36(D)mm

QM-1563

$119.00

Non-Contact Voltage Tester/IR Thermometer

A precise non-contact AC voltage detector and IR thermometer in one. Provides easy and safe testing of mains voltages and heating systems in both celsius or fahrenheit.

- Detects AC voltage up to 1000V with LED indicator
- Precise non-contact temperature measurement
- Automatic range selection resolution 0.1°C (0.1°F)
- Cat III - 1000V
- Dimensions: 155(L) x 24(Dia)mm

QP-2269 WAS $59.95

$39.95
SAVE $20.00

2 in 1 Network Cable Tester & Digital Multimeter

This innovative device is ideal for network installers or technicians and will allow the user to easily check cable integrity or measure AC & DC voltage, etc without needing to carry two separate devices.

- Case included
- Autoranging
- Display: 2000 count
- Category: Cat III 600V
- Size: 162(H) x 74(W) x 44(D)

XC-5078 WAS $99.95

$89.95
SAVE $10.00

AC Clamp Meter for DMMs

This rugged adaptor plugs into your digital multimeter to allow high current AC measurement up to 300amps. This figure is dependent, however on your multimeter's low AC voltage range. The adaptor features a moulded hand guard for increased safety, high quality ABS construction, 3 metre extended curly cord plus shrouded 4mm banana plugs.

- Current range: 0.1A to 300A AC RMS (3V scale)
- Output voltage: 1mV AC per 0.1amp AC
- Working voltage: 600V
- Max jaw opening: 30mm
- Size: 156(L) x 80(W) x 35(D)mm

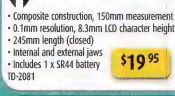
QM-1565

$24.95

Digital Calipers

150mm Digital Vernier Calipers

The digital display is calibrated in imperial and metric units with a corresponding scale etched onto the caliper slide. Perfectly suited to the home handyperson and is the ideal caliper for woodworkers.



- Composite construction, 150mm measurement range
- 0.1mm resolution, 8.3mm LCD character height
- 245mm length (closed)
- Internal and external jaws
- Includes 1 x SR44 battery

ID-2081

$19.95

IP54 Rated 150mm Digital Caliper

Soluble oil, grease, dust and swarf are just some of the hazards measurement tools have to deal with in a workshop. These calipers are IP54 rated to withstand all these nasties.

High accuracy

- Resolution: 0.01mm
- Auto power-off
- Metric and imperial conversion in any position
- Case & battery included

ID-2084

$59.95

Test Equipment Kits

Low Capacitance Adaptor for DMM Kit

Build it yourself

Refer: Silicon Chip Magazine March 2010

Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery and just about any modern DMM.

KC-5493

$34.95

Digital Multimeter Kit

Refer: Silicon Chip Magazine March 2010

Learn everything there is to know about component recognition & basic electronics with this comprehensive kit. With test questions & schematic supplied in the manual, the kit can be geared to an individual or class learning environment, making it an excellent choice for first year trade apprentices.

$24.95

Kit includes: DMM, case, LCD, solder, battery, test leads, PCB, electronic components. (Soldering iron required)

- Comprehensive 18 page learning manual included
- Meter dimensions: 67(W) x 123(H) x 25(D)mm

KG-9250

EXTREMELY PRACTICAL KIT

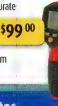
Non-Contact Thermometer with Dual Laser Targeting

Measure the tempeature of any surface from a safe distance with this compact sized non-contact thermometer. With a wide temperature range & laser targeting, this portable instrument is easy to use for quick & accurate temperature checking of any surface.

- Temp range: -50°C to +650°C / -58°F to +1202°F (±1%)
- Dimensions: 146(L) x 104(W) x 43(D)mm

QM-7221

$99.00



DMMs

Data Hold DMM with Backlight

A digital multimeter with lots of features which includes a holster and probes. Excellent for those who are just learning about DMMs.

- 2000 count, Cat II 600V
- Basic DCV accuracy: 0.800%
- 20 range, Transistor & Diode test
- 10A DC current, Data hold
- Dimensions: 145(L) x 65(W) x 35(H)mm

QM-1523 WAS $14.95

$11.95
SAVE $3.00

Frequency DMM

Features include extra large display with 25mm high digits frequency, temperature and transistor tester. Also included is a protective holster with hanging clip and tilting bail, low battery indicator, overload protection & test leads.

- 32 range
- Display: 2000 count
- Category: Cat II 600V
- Dimensions: 200(H) x 95(W) x 45(D)mm

QM-1320 WAS $29.95

$24.95
SAVE $5.00

Micro Sound Level Meter

This little meter is ideal for environmental, safety and sound system testing. It has a fast response time for transient measurements and is A-weighted for the frequency range of human hearing.

- Frequency range: 31.5Hz - 8kHz
- Measurement range: 40 - 130dB
- 1 x 9V battery included
- Accuracy: ± 3.5dB @ 1kHz
- Dimensions: 150(L) x 55(W) x 32(D)mm

QM-1591

$39.95

Getting The Most From Your Multimeter

This book is primarily aimed at beginners, and those with a limited knowledge of electronics. Chapter 1 covers the basics of analogue and digital multimeters. Chapter 2 various methods of component. Circuit testing is covered in chapter 3, where subjects such as voltage, current and continuity checks are discussed.

- Softcover 102 pages • Size: 110 x 178mm

BB-7034

$17.95

Limited stock on sale items.
All Savings are based on Original RRP

Jaycar Electronics
Better, More Technical

USB Car Chargers

new

For anyone with a mobile phone or other device that charges from a USB socket, these are the perfect solution for recharging in the car. Simply plug into your car's cigarette lighter socket, and you have a readily available USB charging source. Two models are available: single and double sockets.

1.0A USB Car Adaptor
Input: 10-18VDC
Output: 5VDC, 1.0A
Dimensions: 24(dia) x 52(L)mm
MP-3662 $9.95

3.1A Dual USB Car Adaptor
FROM **$9.95**
Input: 10-18VDC
Output voltage: 5Vdc, 2.1A + 1.0A (3.1A total)
Dimensions: 26(dia) x 60(L)
MP-3664 $19.95
Due Early February 2011

2.4GHz Rear View Mirror Reversing Camera Kit

Wireless technology makes for easy installation. The monitor fits securely over your existing rear view mirror and can be quickly removed when needed. The brackets are adjustable so it will fit mirrors from 55 - 85mm wide and it's powered simply by plugging it into a cigarette lighter socket. It incorporates a reversing camera that transmits video signals via 2.4GHz band to the monitor so there's very little wiring to be done. The camera can be mounted internally or externally.

new

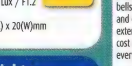
$199.00

- LCD: 3.5"
- Power: 12VDC
- Dimensions: 280(L) x 95(H) x 26(D)mm

QM-3795

Flush Mount Mini Waterproof Camera for Cars or Trucks

Designed for use in vehicles to give drivers a clear view of car or truck blind spots. A lengthy 730mm composite RCA cable and the appropriate sized hole saw are included.



Camera:
- Sensor: CMOS
- Resolution: 628 x 512 pixels
- Minimum illumination: 0 Lux / F1.2
- Power supply: 12VDC
- Camera dimensions: 31(L) x 20(W)mm

$89.95

QC-3513

LED Festoon Lights

Replace your interior lights with LED replacements and never change a blown globe again. 360° arc of illumination for even light distribution.

new

8 x White 31mm 12VDC
ZD-0481

8 x White 36mm 12VDC
ZD-0483

$16.95 each

USB Car Charger for iPad® /iPhone® /iPod®

Charge your Apple® devices while you're driving. Simply plug into the car's cigarette lighter outlet. The USB port puts out a huge 2.1A to fast charge an iPad®.

Unit includes a USB charging cable to suit iPod®/iPhone®/iPod®.
MP-3657

new

$24.95

Universal GPS/PDA Car Charger

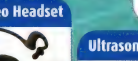
Ideal for powering a GPS or other mobile device. This handy adaptor plugs into any 12 or 24V cigarette lighter socket and provides 5VDC output. It also has an auxilliary cigarette lighter socket so you can use other devices while it's in use. Lead length 1.2m.

MP-3046 WAS $29.95

$19.95
SAVE $10.00

Remote Control Under Car LED Kit

The kit comprises four 630mm long PVC strips with 12 groups of three LEDs and 2.5m cable, making it easy to position the strips for optimum effect. All you need to do is connect 12V. Switchable by remote control between red, green and blue. Ideal for street or show.



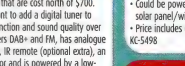
new

$89.95

SL-3955

Bluetooth® Stereo Headset

Easily paired with any Bluetooth® device such as a mobile phone or computer. Extremely light and comfortable. Microphone for Bluetooth® hands-free capability and lithium-ion rechargeable batteries which will provide hours of use. USB cable included.

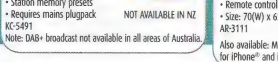


AA-2067

$49.95

DAB+/FM Digital Radio Kit

There are very few digital radios available as hi-fi components and the few that are cost north of $700. Many hi-fi enthusiasts want to add a digital tuner to their system and want function and sound quality over bells and whistles. It covers DAB+ and FM, has analogue and optical audio outputs, IR remote (optional extra), an external antenna connector and is powered by a low-cost mains plugpack. The kit is complete with everything, including the case. See website for full specs.



- Digital station info display
- RCA and optical audio output
- External antenna connection
- Station memory presets
- Requires mains plugpack

$399.00

NOT AVAILABLE IN NZ

KC-5491

Note: DAB+ broadcast not available in all areas of Australia.

Entertainment Headrests

7" TFT Colour Monitor with Headrest

If you already have a DVD player or other video source in the car, such as the QM-3776 (below) you can set this up as a second or third monitor as part of system. This model features a 7" TFT screen, with two composite video inputs and IR remote control and is identical in appearance to the QM-3776 - making them an excellent "pair" for a complete in-car video entertainment system.

- Screen dimensions: 7 inches
- Resolution: 1440 x 234 (16:9/4:3 selectable)
- System: NTSC/PAL
- Power: 12VDC
- 2 composite video inputs
- Headrest dimensions: 280(W) x 200 (H) x 110(D)mm
- Dark grey leather-look upholstery

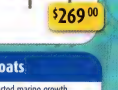
QM-3766

new

$199.00

Headrest with built in 7" Monitor and DVD player

Will not only play DVDs, but also your video files such as DivX, MPEG4, etc, and even play videos on your USB stick or SD card. You can also connect an Xbox360® or Playstation3® via the A/V input. Also includes in-built games system (games CDs included) and two games controllers and IR remote control.



- Screen dimensions: 7 inches
- Resolution: 1440 x 234 (16:9/4:3 selectable)
- Power: 12VDC
- Supports infrared earphones
- Supports USB/MS/MMC/SD card
- Headrest dimensions: 280(W) x 200(H) x 110(D)mm

QM-3776

$269.00

Ultrasonic Antifouling for Boats

Many of you know that you can buy $3-$,000 imported marine growth electronic antifouling systems. Jaycar, with Silicon Chip have developed a similar system based on this technology and information in the public domain. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in sturdy polyurethane housings. By building yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer , potting and gluing components and housings. Research reveals only one transducer is needed for boats under 32ft. Basically all parts supplied in the project kit including wiring.

- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/wind generator
- Price includes epoxies

KC-5498

$249.00

In-Car Bluetooth® FM Modulator

Play music or even video stored on an SD card, USB stick or any other media device through the FM radio in your car. You can control the playback by remote control or via the steering-wheel mounted remote unit and pair it with your Bluetooth® mobile phone for hands-free operation. A remote earpiece is included which enables you to make and receive calls completely wirelessly.

- 2.5" colour LCD
- Supports MP3, WMA formats
- USB cable and 3.5mm audio cable included
- Remote control included
- Size: 70(W) x 65(H) x 22(D)mm

AR-3111

$99.00

Also available: MP3/USB FM Modulator for iPhone® and iPod® AR-3113 $49.95 Due Early February

new

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

Alarm kits

8 Zone Wireless Alarm Kit

Wireless alarms are a great way to add security to your house, apartment or business without the daunting and invasive process of running cables everywhere. This system learns what sensors are connected and the part arm function allows you to protect certain zones while others are disarmed. The kit has everything you need to make your place secure.

Kit contents:
- Siren and bellbox
- Keypad, PIR sensor
- Reed switch, 9V plugpack

Features:
- 8-zones, 3 mode arming
- Battery backup
- Learning function
- Panic alarm

LA-5150

$219.00

Spares sensors and accessories also available:

	LA-5151 $39.95
PIR Sensor	LA-5152 $34.95
Reed Switch	LA-5154 $14.95
Battery Pack	LA-5155 $24.95
Remote Control Key Fob	

10 Zone Wired Alarm Kits

Fully configurable and programmable, these wired alarm kits give you complete control over a professional system for your home or business. Each comes with a central controller and the sensors you need to get a basic system up and running, then you can add sensors and functionality as required. Up to four remote keypads can be installed at up to 100m range and each can be named for easy identification.

- 10 programmable zones • 4 access levels
- Walk test mode • Events memory in keypads
- Programmable timers for entry, exit and alarm duration

Alarm with LED Controller
- 1 x Reed switch
- 2 x PIR sensor
- 50m cable

LA-5560 $299.00

Both units supplied with SLA batteries & bell box strobes

Alarm with LCD Controller
- 2 x Reed switch
- 4 x PIR sensor
- 2 x 50m cable

LA-5562 $399.00

Spare controllers and sensors also available:

LED Remote Controller	LA-5561 $49.95
LCD Remote Controller	LA-5563 $69.95
PIR Sensor	LA-5564 $29.95

LA-5562 shown

DVR Kits with Colour Cameras

These 4 Channel DVR kits are ideally suited to smaller surveillance installations around the home or office. The systems can store over 150 hours of video on the 320GB HDD. Not a PC-based system, but recorded video is indexed in an event log and can be viewed via a computer or external monitor. Complete with weather resistant IR cameras, cables, remote control and mains adaptor.

DVR:
- 4 x camera inputs
- 1 x composite video output
- MJPEG compression
- SATA hard drive interface
- 320GB Seagate SV35 Surveillance Hard Drive Camera

FROM $499.00

Camera:
- 350TV lines
- Inbuilt infrared illumination
- Day/night operation

Additional/replacement camera: QC-3239 $59.95

2 Cameras QV-3020 $499.00
4 Cameras QV-3024 $599.00

3.5" LCD Camera Kit

Connect power and install the camera where needed. The 3.5" TFT LCD gives real-time video monitoring and the microphone in the camera provides audio either through the speaker in the display unit or via headphone outlet. The LCD unit is able to take two AV inputs, so you can add a second camera if required. 20m power/video cable and mains plugpack included.

- IR illuminator
- CMOS sensor
- Dimensions: 130(W) x 80(H) x 22(D)mm

QC-8007

$149.00

Spare camera also available: QC-8009 $69.00

Keypad Shed Alarm

Simple and effective garage or shed alarm that consists of a keypad and single reed switch for a door or window and 5m of cable for easy DIY installation. It can be used as an instant alarm with an entry delay or as a door chime to announce entry. Powered by a single 9V battery.

- Dimensions: 162(H) x 85(W) x 32(D)mm

LA-5214

$29.95

CMOS Outdoor Camera with IR

Versatile CMOS outdoor camera with IR illuminator. Supplied with an 18m power/video cable, it could be used as a stand-alone or as an additional camera for DVR kit (QV3020, QV3024 and QV3030).

- 350TV lines
- Day/night operation
- 6.0mm lens
- 18m cable
- 180mm adapter cable - DIN to BNC & DC plug
- 12VDC 300mA power adaptor
- Dimensions: 85(L) x 58(Dia)mm

QC-3239

$59.95

Solar Powered Shed Alarm Kit

Not just for sheds, but for a location where you want to keep undesirables out but don't have access to mains power e.g a boat on a mooring. It has 3 inputs so you can add extra sensors as required, plus all the normal entry/exit delay etc. Short form kit only - add your own solar panel, SLA battery, sensors and siren.

- Supply voltage: 12VDC
- Current: 3mA during exit delay; 500µA with PIR connected
- Alarm period: approximately 25 seconds to 2.5 minutes adjustable

KC-5494

$29.95

Visible Deterrent To Intruders

Partner with a dummy camera or two for a complete faux security system.

CCTV Sticker Large Size
- Bright yellow to attract attention
- Dimensions: 110(L) x 110(W)mm

LA-5101

$3.95

Solar CCTV Warning Sign
- Built-in solar cell
- Flashes when there is light available
- Double sided tape included
- Dimensions: 80(L) x 80(W)mm

LA-5103

$14.95

Recording Cameras

1.3MP Mini Digital Spy Camera

This clip-mount mini digital recorder delivers the ultimate in discrete portable photo and video recording. It has limitless applications including fixed security surveillance, babysitting monitoring, web camera and general home videos. It also takes a MicroSD Card supporting up to 8GB of memory and comes with a lanyard, USB lead, pocket clip and stand.

- 1.3MP camera
- Supports up to 8GB MicroSD card
- 2GB built in internal memory
- Supports AVI formats
- Rechargeable Li battery lasts for 2 hours of non-stop recording
- Size: 57(H) x 22(W) x 19(D)mm

QC-8003

$69.95

Thumb Size

Ultra Portable HD Video Camera & Recorder

Length of recording time will depend on card capacity and definition, but the internal memory will hold about 50 minutes of standard definition, 20 minutes of high definition video or over 3000 photos. The internal lithium battery recharges via USB and will provide about 4 hours of use. Pocket clip and desk stand included.

- 3MP camera
- Supports up to 32GB MicroSD card
- 2GB internal memory
- Supports AVI format
- 350mAh rechargeable battery
- 1280 x 720p resolution
- Size: 23(H) x 78(H) x 14(D)mm

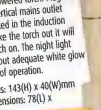
QC-8005

$119.00

Weighs only 25 grams

Night Light With LED Torch

A product that smartly combines a night light and a 6 LED powered torch. Plug the night light into a vertical mains outlet with the torch docked in the induction charging cradle. Take the torch out it will automatically switch on. The night light base emits a soft but adequate white glow and has 3 modes of operation.



- Torch dimensions: 143(H) x 40(W)mm
- Night light dimensions: 78(L) x 60(W) x 62(H)mm

ST-3141

$19.95

Limited stock on sale items.

All Savings are based on Original RRP

www.jaycar.com.au

Jaycar Electronics

Better, More Technology

CREE LED Rechargeable Spotlight

Super bright LED spotlight with 247 lumen output switchable between half and full power output. AC and 12VDC car charger are both included so it's ideal for boating, camping and other outdoor activities. It also has an emergency SOS mode as well as a handy flip-up work stand for changing tyres etc. Robust ABS construction.

- Work stand
- LEDs indicate battery status
- Weatherproof
- Multi brightness modes
- Size: 225(L) x 130(Dia)mm

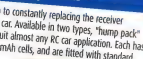
SF-3309

New

$49.95

6.0V 1600mAh Ni-MH RC Receiver Battery Packs

The perfect solution to constantly replacing the receiver batteries in your RC car. Available in two types, "hump pack" and "flat pack", to suit almost any RC car application. Each has five 1.2V 1/3A 1600mAh cells, and are fitted with standard 2-pin JST connectors.



Hump Pack

Dimensions: 52 x 32 x 32mm, 60mm lead

SB-2302 WAS $29.95

$19.95 each

SAVE $10.00

Flat Pack

Dimensions: 86 x 32 x 17mm 80mm lead

SB-2304 WAS $29.95

12V 7.2Ah SLA Battery

Perfect for use as an emergency power source with alarms and computer peripheral terminals as well as portable DVD players, lights or solar panels for remote power.

12V, 7.2Ah

Leak proof construction

Usable and rechargeable in any position

Size: 151(L) x 65(D) x 101(H)mm

2486 WAS $29.95

$24.95

SAVE $5.00

See in store or online for full range of SLA batteries available.

Wireless 3 Outlet Mains Controller

Simply plug in any mains appliance rated up to 10A and use the remote to turn each one on or off individually, or control all of them together. One of the outlets also has an LED night light that's operated with the remote. Has real benefits for the elderly or disabled.

- 433MHz
- Remote battery included
- Remote measures: 125(W) x 45(H) x 17(D)mm

MS-6142

$44.95

With LED night light

Deluxe Mains Power Meter with CO_2 Measurement

In addition to telling you the cost of electricity consumption of an appliance plugged into it and the amount of power used in kilowatt hours, it will tell you how many cumulative kg of CO_2 the appliance is putting into the atmosphere.

- Extra large LCD for easy reading
- Dimensions: 120(L) x 58(W) x 40(H)mm

MS-6118

$29.95

Buy 3 for $75.00 SAVE $14.85

HDMI Wall Plates with Flylead

Standard Australian/NZ GPO mount with HDMI sockets for AV installations. Comes with a single or dual HDMI port with flexible flylead for better inner wall clearance.

Single Socket PS-0281 $14.95

Double Socket PS-0283 $24.95

FROM **$14.95**

New

5-Metre 2 Pin Power Lead

Black 240V 2 pin power lead as used in many appliances.

- 5AA approved
- 5 metre long
- Universal round IEC 77 connector

PS-4117

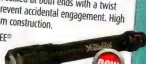
$11.95

New

High Powered CREE® Torches

750 Lumen X-Glow CREE® LED Powered Torch

A worthy new addition to the X-Glow series of CREE® LED torches. This is the kind of torch you need for serious outdoor activities. Silicon gasket sealed at both ends with a twist switch at the base to prevent accidental engagement. High quality rugged aluminium construction.



- LED Type: 1 x MC-E CREE® X-Lamp White LED
- Requires 4 x D batteries
- Dimensions: 355(H) x 52(Dia)mm

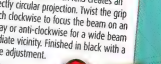
SF-3451

New

$99.00

250 Lumen LED Torch with Adjustable Beam

High powered 250 lumen CREE® LED torch with a fully adjustable beam spread. The thick convex lens creates an incredibly sharp, perfectly circular projection. Twist the grip at the head of the torch clockwise to focus the beam on an object up to 200m away or anti-clockwise for a wide beam to light up your immediate vicinity. Finished in black with a tactical switch for mode adjustment.



- Requires 3 x D Batteries
- Burn time: 100 hours
- Dimensions: 250(H) x 54(Dia)mm

SF-3455 Due Early February

New

$49.95

Cree® Replacement Globes

Drop-in replacements for standard GU10 downlights. White or warm white, 240V mains operation, equivalent light output to a 50W halogen globe, far less power, many times the life span.

- 3 x 2W CREE® LEDs
- 240V operation
- Dimmable
- White = 450 lumens
- Warm white = 310 lumens
- Power consumption = <6W

White ZD-0374 **Warm White** ZD-0375

New

$59.95 each

Three Stage 48V 9A Battery Charger

Suitable for golf buggies, electric wheelchairs or similar applications. It monitors & manages your charging with three different stages and will maintain the optimum charge level. Compact and lightweight. Includes output cables with eye terminals to attach to your battery.

- Switchable charging modes
- Short circuit, output current, polarity and thermal protection
- LED charge status indication
- Digital Charge Display
- Input: 190 - 260VAC
- Output: 48VDC @ 9A max
- Dimensions: 298(L) x 112(W) x 60(H)mm

MB-3628 WAS $499.00

Great for Golf Buggies

$399.00

SAVE $100.00

ains Laptop Power Supplies

deal spare or replacement power supplies for on the go or to at the office and one at home. Models below are compatible most laptops on the market. On the manual types, switch the voltage to be compatible with the laptop, automatic models s for you. See online for tibility with your laptop.

etbook Power Supply

r output: 40W

e range: 12 - 24VDC

nectors

atic selectable voltage

sions: 172(L) x 69(W) x 40(H)mm

$49.95

70W Universal - Automatic

- Power output: 70W
- Voltage range: 8.4 - 24VDC
- 16 different connectors
- Automatic selectable voltage
- Dimensions: 110(L) x 52(W) x 25(H)mm

MP-3320

$59.95

150W Universal - Automatic

- Power output: 150W
- Voltage range: 12 - 20VDC, 22-24VDC
- 16 connectors
- Automatic selectable voltage
- Dimensions: 88(L) x 39(W) x 29(H)mm

MP-3473

$129.00

90W Universal - Automatic

- Power output: 90W
- Voltage Range: 15 - 24VDC
- 16 connectors
- Automatic selectable voltage
- Dimensions: 154(L) x 58(W) x 37(H)mm

MP-3475

$79.95

Also available:
90W Manual laptop power supply
MP-3476 $69.95

tter, More Technical

All Savings are based on Original RRP

Limited stock on sale items.

To order call 1800 022 888

Great Savings On CB Radios

Advanced 2 Watt 38 Channel UHF Transceiver with CTCSS

This advanced UHF transceiver is certainly no toy - providing a range of up to 10km line-of-sight. Save battery power by switching to the low setting (500mW) for local communications such as around the campsite. Includes a rechargeable li-ion battery and plugpack charger.

- CTCSS
- Hi/Lo power output
- Auto squelch & roger tone
- Backlit LCD
- Low battery display
- Stop watch
- Dimensions: 120(L) x 57(W) x 35(H)mm

DC-1047 WAS $99.95

Spare 600mAh Li-Ion Battery DC-1048 $29.95

$79.95
SAVE $20.00

0.5W 38 Ch UHF Transceivers

Includes two 38 channel UHF CB radios complete with rechargeable batteries, dual charger cradle and a range of accessories. They have 0.5 watt output for up to 5km transmission range and CTCSS function. Ideal for bushwalking, camping, sports etc.

- Sold as a pair
- No licence required
- 38 channels and 38 sub-channels

DC-1026 WAS $114.00

See in store for full range of UHF Transceivers up to 3W and ranges to 12Km

$99.00
SAVE $15.00

1:10 Scale Remote Control Off-road Electric Cars

Don't be fooled by the price tag, these are serious 1:10 scale electric off-road remote control racing cars! Each is constructed around a lightweight hardened plastic chassis, and features front and rear fully adjustable independent suspension with oil-dampened shock absorbers, full-time shaft-driven 4WD with front and rear geared differentials, lightweight aluminium top plate for extra chassis strength, hi-speed steering servo, electronic speed controller (ESC) and hi-torque RC540 brushed motor. Both the buggy and monster truck are supplied fully assembled and "ready-to-race", complete with 7.2V 1800mAH NiMH rechargeable battery pack and mains charger. Requires 8 x AA batteries for the controller. Recommended for ages 12+. See website for full specifications.

$199.00
SAVE $30.00

GF-3670

1:10 Scale!

GF-3672

$219.00
SAVE $30.00

Buggy GF-3670 WAS $229.00
Monster Truck GF-3672 WAS $249.00

Mini Wireless Weather Centre

Keep up-to-date with current and forecasted atmospheric conditions at a glance. With two small outdoor weather sensors, it precisely measures, records and forecasts all the basic weather parameters and displays them on an LCD screen. Handy features include three forecast icons based on changing barometric pressure.

- LCD screen: 135(W) x 34(D) x 140(H)mm
- Outdoor wind sensor: 110(H) x 180(D)mm
- Temp/bar/humidity sensor: 57(W) x 57(D) x 160(H)mm

XC-0349

$99.00

Emergency Caution Light

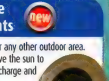
Contains a strong magnet for placement on vehicles in an emergency situation and is visible up to 800 meters away.. With built in IC controlled LED flash, this light has 9 user-selectable flash patterns. Perfect for cars, boats and watercraft safety.

- Requires 2 x AAA batteries
- Dimensions: 105(Dia) x 35(H)mm

SF-3201

Compact size

$19.95



Solar Rechargeable In-Ground LED Lights

NEW

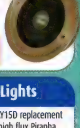
Light up your path, garden, patio or any other outdoor area. Simply set into the ground and leave the sun to do its thing - they automatically recharge and come on when darkness descends.

- Robust aluminium construction
- Size: 80(W) x 28(H)mm

SL-2751

Due Early February

$34.95



Ni-MH Rechargeable Batteries

These high capacity batteries provide the best in portable AA or AAA power. Supplied in a pack of 4.

900mAh AAA
SB-1739 $11.95
2,500mA AA
SB-1738 $19.95
2,000mAh AA
SB-1737 $14.95

FROM $11.95

Savings!

5-in-1 Jump Starter - Inverter - Compressor - Work Light - Charger

Far more than your average jumpstarter this unit has an impressive set of features for a hundred different uses. Tucked in on either side are two tough insulated battery clamps for all your jumpstarting needs, on the front panel you have 2 x 12VDC cigarette lighter sockets for operating 12V appliances, a 5 LED worklight and two dial indicators for air pressure and charge status. Powered by the internal 12V 18Ah SLA battery, it even has a 400W inverter to charge your laptop, etc. See Website for specifications.

Dimensions: 220(L) x 215(W) x 295(H)mm

MB-3594

$149.00

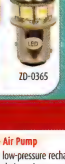
LED Replacement Auto Lights

Utilising SMD LED technology, these LED BAY15D replacement globes offer a 360° arc of illumination and high flux Piranha LEDs for high brightness. Suitable for parkers, reverse, tail and brake light replacements.

9 x White BAY15D for Stop/Tail
ZD-0361
9 x Red BAY15D for Stop/Tail
ZD-0365
9 x White BA15S
ZD-0367
9 x Amber BA15S
ZD-0369

$24.95 each

Suitable for off-road, marine and show use only



ZD-0365

LCD Weather Station Keyring

A weather station that fits in the palm of your hand! Shows weather forecast, temperature, humidity, time, date and moon phase. It also has an alarm clock with snooze button. Complete with inbuilt LED torch and compass.

- Batteries included
- Celsius or Fahrenheit
- Max/min temperature and humidity memory
- Dimensions: 93(H) x 50(W) x 18(D)mm

XC-0341

$19.95

12V Camping Accessories

12V Car Kettle

Plugs into a car's cigarette lighter socket and holds up to 550ml. This travel-friendly kettle makes up to 4 cups of hot beverage or soup.

- 2 cups, strainer and mounting bracket included
- Dimensions: 235(H) x 95(dia)mm

GH-1380

$17.95

12 Volt Portable Stove

Cooks, warms or reheats at up to 125°C. Deep lid design, with a case made from durable ABS plastic and carrying handles.

- Measures: 265(L) x 180(W) x 155(H)mm

YS-2808

$49.95

Rechargeable Air Pump

A high-volume low-pressure rechargeable air pump that is recharged via mains power or car charger.

- Includes hose and two air nozzle fittings
- Mains adaptor (240VAC) and car charger (12VDC) included
- Dimensions: 205(L) x 105(W) x 130(H)mm

GH-1119

$39.95

12V Air Pump

Great to use on air beds, beach balls, lilojackets and rafts etc. Powered from your vehicle's 12 volt outlet, its supplied with 3 sized nozzles to suit most inflatables.

GH-1110

$12.95

Limited stock on sale items.

All Savings are based on Original RRP

www.jaycar.com.au

Jaycar Electronics
Better, More Technical

Schools Back! Be Up & Ready

Mini Talking Alarm Clock

Never be late again as you wake to the sounds of a cuckoo, crow, chimes or a synthesised voice announcing the time. The clock can be set to announce the time on every hour or when the top mounted button is pressed.

- Silver in colour
- 2 x AA batteries required

XC-0238 WAS $12.95

$9.95
SAVE $3.00

Multifunction Radio Alarm Clock

Project the time and outdoor temperature on your ceiling and it has six realistic nature sounds that create a true-to-life outdoor ambience to slowly lull you to sleep at night or peacefully awaken you in the morning. AM/FM radio, dual alarms with snooze function, and blue backlit LCD with low/high settings.

- 6V mains adaptor and outdoor temperature sensor included
- Requires 2 x AAA batteries
- Size: 160(W) x 180(H) x 42(D)mm

AR-1755 WAS $49.95

$39.95
SAVE $10.00

Blue LED Wall Clock with Alarm & Remote

Eye-catching LED wall clock with brilliant bright blue numeric display. With easy-to-read numerals 2.5-inches tall, its fresh design will suit contemporary homes as well as modern offices, workshops, waiting rooms etc. Powered either by mains adaptor or 9V battery.

- 12/24 hour mode with alarm clock function
- Remote control included
- Mains adaptor included
- Dimensions: 310(W) x 33(D) x 164(H)mm

AR-1759 WAS $69.95

$59.95
SAVE $10.00

5.5" Graphics Tablet

Using a graphics tablet is completely natural, more comfortable and far more accurate than a mouse, with higher resolution and pressure sensitivity. The pen has user defined buttons and "hotspots" around the border of the tablet. Paint, draw, write or touch up. Absolutely essential tool for graphics designers, photographers or other creatives.

- Battery and software included
- Windows 2000, XP, Vista or Mac
- Dimensions: 205(W) x 190(H)mm

XC-0356 WAS $79.95

$59.95
SAVE $20.00

USB Wireless Rechargeable Mouse

With an ergonomic design to perfectly fit into your hand, an optical lens for precision aiming and a rubber-like finish which prevents it slipping in your hand, this mouse stands out as a very modern piece of equipment.

- USB interface - Plug and Play
- Compatible with Win 95/98/2000/NT/ME/XP

XM-5132

$34.95

Buy XM-5132 mouse and recieve a FREE Jaycar Mouse pad with your purchase.

600VA 375W Line Interactive UPS

Compact and completely self-contained, this is the ideal backup solution for your data or other important equipment. It has 3 surge-protected outlets as well as 3 outlets backed up by the UPS. It also has RJ11 ports for protecting phone or fax lines.

- Cold start feature
- Software included
- Rating: 375W, 600VA
- SLA battery: 7Ah
- Supply voltage 220 to 280VAC
- Backup time: 3 min at full load
- Recharge time: 10 hrs
- Output waveform: Step sine wave
- Dimensions: 268(L) x 180(W) x 80(H)mm

MP-5222 WAS $119.00

$109.00
SAVE $10.00

Networking USB 2.0 Servers

Plug this device into your router with the supplied Cat 5 cable then plug in a USB powered product and computers will be able to see and use your USB peripherals from any computer.

1 Port YN-8400 WAS $79.95

$59.95
SAVE $20.00

4 Port YN-8404 WAS $99.00

$79.00
SAVE $20.00

Cool Down Your Laptop

Foldout Twin-Fan Notebook Cooling Pad

Designed for portability and durability this foldout twin-fan cooling pad will help keep your notebook from overheating and is made from strong steel construction that folds neatly into a compact package. Suitable for any size laptop and is conveniently powered by your laptop via USB connection - no need for an extra power supply.

Foldout size: 275(W) x 183(D) x 17(H)mm
Folded size: 170(W) x 65(D) x 17(H)mm

XC-5216 WAS $9.95

$7.95
SAVE $2.00

Notebook USB Cooling Pad

This notebook cooling pad simply plugs into your notebook's USB port and has an inbuilt 18cm cooling fan to dissipate heat. Having one large fan results in it being quieter than other pads with multiple small fans. Featuring four non-slip pads and an ergonomically tilted surface.

- Dimensions: 300(L) x 290(W) x 35(H)mm

XC-5210 WAS $14.95

$9.95
SAVE $5.00

Industrial IP68 USB Keyboard

Dustproof and waterproof to IP68, so if it should ever get dirty simply wipe clean with a sponge. Perfect for industrial, food & beverage, laboratories, garages and even outdoor use. It also comes with a silicone sleeve for added protection. Anti-bacterial rubber construction.

- Full-sized QWERTY layout
- USB connectivity
- Windows 2000/XP/Vista
- Measures: 440(L) x 138(W) x 12(H)mm

XC-5141 WAS $99.00

$59.00
SAVE $40.00

20m USB Extension Lead

new

Extend your USB devices farther and wider with this 20m active USB extension lead. The amplifying circuitry uses power from the USB port to increase the signal strength to ensure the data goes the distance.

- USB plug A to socket A

XC-4124

$49.95

Wind and Solar Powered RC Cars

These mini remote controlled cars will surely entertain and educate curious minds about the concept of wind and solar power. The kits are very simple to build and come with a manual that provides construction details and explains how alternative energy can generate electricity.

- Car size: 60(L) x 30(W)mm

Wind Powered KJ-8838
Solar Powered KJ-8839

$49.95 each

KJ-8838 shown

new

YOUR LOCAL JAYCAR STORE

Australia Freecall Orders: Ph 1800 022 888

AUSTRALIAN CAPITAL TERRITORY
Belconnen Ph (02) 6253 5700
Fyshwick Ph (02) 6239 1801

NEW SOUTH WALES
Albury Ph (02) 6021 6788
Alexandria Ph (02) 9699 4699
Bankstown Ph (02) 9707 2822
Blacktown Ph (02) 9678 9669
Bondi Junction Ph (02) 9369 3899
Brookvale Ph (02) 9905 4130
Campbelltown Ph (02) 4620 7155
Coffs Harbour Ph (02) 6651 5238
Croydon Ph (02) 9799 0402
Erina Ph (02) 4365 3433
Gore Hill Ph (02) 9439 4799
Hornsby Ph (02) 9476 6221
Liverpool Ph (02) 9821 3100
Maitland Ph (02) 4934 4911
Newcastle Ph (02) 4965 3799
Penrith Ph (02) 4721 8337
Rydalmere Ph (02) 8832 3120
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SERVICEMAN'S LOG

Never, ever give up on a computer

Why is it that people who should know better often fail to back-up important files on a hard disk drive? Retrieving data from a faulty HDD in a machine that won't boot can be a lot of work but perseverance sometimes pays off.

Items Covered This Month

- Retrieving data from an Apple Mac
- Earwigs & non-payers
- Now that I've retired
- Non-existent quality control
- Mrs Bleep's new TV antenna

My first story this month comes from W. S. of Numurkah, Victoria and concerns the hoops he had to jump through to retrieve data from a Mac laptop with a faulty hard disk drive. Here it is in his own words . . .

I teach at a secondary college and at the beginning of last year, the decision was made to go to Mac laptops for the staff and students. This subsequently proved to be a steep learning curve for both the teachers and IT staff, as they came to grips with the Mac OS (operating system) after eight years of using Windows XP.

Recently, our computer technician Dave came to me with a 6-month old MacBook and noticeably less hair than the last time I saw him. The problem was that the Mac would not boot. Instead, it was giving the spinning beach-ball of death and a teacher had years of work on it that he was now unable to retrieve. It's the old, familiar story . . . "I was going to back it up but didn't get around to it".

Now if the machine had been a PC, the files would be easy to retrieve – you just phone the supplier and ask if it's OK to pull the hard drive out. The answer is always "yes", so you simply remove the drive, pop it into a desktop PC and copy the files across.

With a Mac, it's a different story. In this case, the answer is always "no, removing the drive will void the warranty and you should send it back to the factory". And so that's how the laptop found its way into my hands. Its owner was not willing to risk the factory losing all his years of work and since I have experience with Linux and a history of fishing computers out of the dumpster and getting them to work again, I was just the person to get him out of trouble!

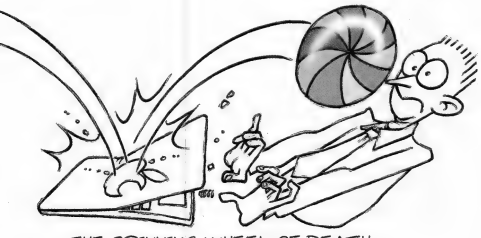
The first thing I did was insert the Mac operating system disc, turn the machine on and hold down the option key to get it to boot from the CD-ROM. Macs don't have a BIOS screen like a PC – instead, there are a number of keys that can be pressed on start-up to make the machine boot from different disks.

All seemed to go well initially and the resulting installation screen gives you some options to repair the operating system using a program (sorry, "application") called "Disc Utilities". It has a number of menus, including first aid, erase, partition, RAID and restore. Unfortunately, these would start up, make me wait for an hour or so and then fail, with an error message stating that the hard drive had lots of bad sectors.

It turned out that Dave and the other three computer technicians had already tried this, as I found out later (much to my annoyance). It was time for "Plan B", so I downloaded the latest version of Puppy Linux and made a boot disk. Puppy is a very small operating system (about 100MB) which can run straight from the CD and is great for getting old machines running and retrieving data. The Mac fired into life and Puppy was quite at home, with every thing working correctly.

Well, almost – the problem was that Puppy couldn't find the hard drive and I was beginning to understand why Dave had lost so much hair. It turns out that the Mac uses its own journaling file system called HFS+ which Puppy doesn't recognise.

And so on to "Plan C". I have used Ubuntu (another Linux OS) for a fair while now, so I thought I would give that a go. So in went the newest version of Ubuntu (10.10) but no matter what I tried, the Mac would not boot



THE SPINNING WHEEL OF DEATH

~I EXPLAINED TO THE CUSTOMER THAT THE UNIT HAD FAILED BECAUSE IT WAS CHOKED UP WITH INSECTS

up from the CD. However, the same disk fired up a PC without a problem which only added to my frustration.

Acting more out of curiosity than anything else, I pulled out an older Ubuntu 9.04 CD and gave that a try. To my surprise, the Mac came to life and as a bonus, it had found the hard drive and I could open files. All was good in the world again for about a minute, until I realised that even though I could see the files and open some of them, it was a different story when I tried to copy them. Instead, it would come back with an error message which stated that I did not have permission to do this.

It was time for "Plan D". I quickly figured out that the USB portable hard drive I had been trying to copy the files to had also been formatted to Mac's journalled system and Linux can have problems with writing data to that system. So I grabbed a more Linux-friendly USB drive formatted to FAT32 but I was still getting the permissions error message if I tried to copy straight to the USB drive. However, if I opened a document, it could be saved to the USB drive without problems. Of course, this would be time-consuming and in any case, it was not possible to transfer all files in this way as some could not be opened with Ubuntu.

"Plan E" was now looking good. Fortunately, Ubuntu has a great online forum and help site, so I spent a couple of hours trolling through this. Eventually I came across a suggestion to use the command "sudo nautilus" (at my own risk) in a terminal window. I gave it a go and it opened up the "Places Menu" in a new window. From there, it was simply a matter of dragging and dropping the files onto the external USB drive.

It's easy when you know how and Dave still quizzes me on how it was done.

As for the laptop, this was sent back to the supplier for repair. It subsequently returned with a new hard drive and all the data was then copied back onto it. Dave now wants to know if I can do the same thing to another one with a broken CD-ROM but that's going to call for "Plan F"!

Earwigs & non-payers

Not all repair jobs (or customers for that matter) are pleasant. T. F. of Chinderah, NSW recently had one such experience. Here's his story . . .

Some repair jobs literally give me the "creepy crawlers" and I sometimes surprise myself at the unusual lengths that I go to, to keep customers happy.

Some time ago, a customer brought in a vertical grille for repair, complaining that it wouldn't heat up. I plugged it in while the customer was there to confirm this and it was just as he said.

After the customer had left, I turned the grille upside down on my workbench and removed the screws from the cover. As I did so, a pile of black gunk fell out and onto the bench. I reached for my dustpan but before I could sweep the mess up, the "gunk" started to move and spread. I then realised that it was actually a mass of earwigs (small insects) and they were intent on reaching another dark hiding place as quickly as possible.

My first instinct was to preserve my work area from this revolting, heaving mass of alien beings. So without much thinking, I brushed the mass off my bench and onto the floor. I was to quickly regret this action – the creatures were gaining mobility and began rapidly spreading over the floor and even over my shoes.

What's more, they were still pouring from the grille and I couldn't find my insect spray to deal with them.

I panicked, scooped up the grille and rushed outside with it, still dropping earwigs as I ran. Once outside, I was more concerned about the possibility of the creatures burrowing into my shoes and between my toes, so I quickly removed my shoes and socks.

In the meantime, I left the grille out in the sunlight, while earwigs ran everywhere. I eventually disassembled it outdoors, so that the few remaining earwigs would not be brought back into my workshop.

Back in the workshop, I found that the grille wasn't heating up because earwigs had been crushed between the thermostat's switch contacts. The result was a horrible, blackened mess inside the thermostat housing. I fitted a new thermostat and explained to the customer that the unit had failed because it was choked up with insects.

Twelve months later, the customer returned, again complaining that the grille wouldn't heat up. He even brought along my account to show me that he had paid for the repair and he insisted that my work must have been faulty. I explained that the repair was long past the warranty period but it is funny how some people seem to lose their understanding of English at these times.

This time, I took the grille out into the carpark before I opened it. And sure enough, there were about 10

million earwigs inside and as before, the thermostat was choked. This time, after I had carefully cleaned it out, I glued some fly wire mesh over the thermostat's ventilation slots. My reasoning was that this would keep the earwigs away from the thermostat contacts and avoid another episode.

Unfortunately, the customer stubbornly maintained that my repair had not been good enough the first time and he refused to pay. In the end, there was just no reasoning with him, so I bluntly told him that I would be unable to do any more work for him in the future. I don't need customers like that.

In the end, he left happy at not having to pay again and I was happy to be rid of both him and his unpleasant repair jobs.

Now that I've retired

My next story comes from B. W. of Curtin in the ACT. All he wants is a bedside alarm clock that works in 24-hour format, preferably with a seconds display, but it's proving to be a bridge too far. Here's how he tells it . . .

Many years ago, in 1967, I built myself a clock using an "ArcherKit" from Tandy. This was a 6-digit unit that used individual fluorescent tubes to display blue/green numbers about 25mm high. It was mains-frequency locked, worked in 24-hour time and had no alarm.

I assembled it one rainy day while on holidays in Southern Queensland, before that area joined the National Grid. When it was completed, I was amazed to discover that the mains clocks in that area varied by ± 90 seconds over the day, running fast around dawn and mid-afternoon, then slowing during the breakfast and early evening peak loads.

Despite its age (over 40 years now), this clock still runs and now always has the "right" time, holding within a second or two of the radio "pips". It is our "master clock" and all reference at home is back to it.

In 1968, I took up a shift-work position and decided that I would like a digital alarm clock. The ArcherKit could not be modified but an appropriate clock chip with a 4-digit, red LED display was being advertised in "Electronics Australia". I mounted the chip and display board on some Veroboard, built an alarm oscillator/amplifier, linked up the necessary switches and a loudspeaker, and carefully put the whole Heath Robinson assembly into a metal diecast box.

The subsequent smoke test revealed that everything was OK, except that I had mounted the whole thing upside down! I didn't have the time then to re-work a new box so the clock was pressed into service with its rubber feet facing up. It remained that way for more than 40 years until, earlier this year, I realised that I now had time to "fix" it.

Unfortunately, I had forgotten how sensitive CMOS devices can be and I destroyed the clock chip in the process. Feeling somewhat miffed at this, I threw the whole thing in the bin which, with the benefit of 20/20 hindsight, was a mistake. It turns out that the clock chip is still available from three different manufacturers.

My attempts to buy an alarm clock with red LEDs that worked in 24-hour format proved worse than frustrating. In the end, I settled on a 4-digit unit with a green display. Unfortunately, domestic static indicated that the readout was unacceptably bright at night and so the search continued, with clock/radios as well as just plain alarm clocks now included.

I eventually found an Akai unit with an orange/yellow display that I could modify to 24-hour time. However, the (now 24-hour) 4-digit display does not dim enough at night and it was decreed to be too big and too bright. As a result, I was told to look for something more suitable – after all, I have the time, since I'm now retired!

I next found a Kambrook KCR40 (with red LEDs) which was advertised, in store, as having a 12/24-hour display. I bought this, downloaded the chip data sheet and re-set the jumpers for 24-hour time and 50Hz. The chip obviously ran in 24-hour format, according to my scope, but the display showed either a '1' or just the 'b' segment of the leading digit. However, power was available on pin 1 of the chip to drive the a, g, e & d segments to make a '2'.

I rang Kambrook but they do not put phone calls through to service personnel and a subsequent letter instructed me to return the clock to the retailer "in its original condition" for a refund!

I tried to drive the individual segments, when isolated, by battery but still nothing. Dismembering the display then revealed that although the display board has provision for the six

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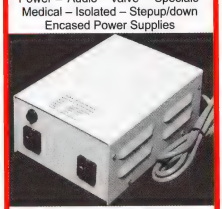

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~MY EYESIGHT & HAND STEADINESS ARE NO LONGER UP TO 1968 STANDARDS

needed LEDs, four LEDs have never been mounted!

It's just as well that I have retired – I now have the time to break off the spot welded LEDs and resolder 36-surface-mount LEDs (all the same brand to ensure even brightness). However, soldering in these 1.6 x 1.6mm surface mount LEDs is not easy, as my eyesight and hand steadiness are no longer up to 1968 standards.

I've also though about changing the displays on the Akai unit, seeing I now have so much time on my hands! For now though, I think I've had enough of fiddling with clocks

By the way, many kitchen appliances have a 24-hour display by default on the clock, so why isn't this at least an option on a bedside alarm clock? What's more, have you ever tried to buy a 4-digit watch with no seconds display or an analog watch without a second hand? These features are standard on those items, so why are they missing from bedside clocks?

Non-existent quality control

Sometimes, even the most basic faults can slip through quality control as P. W. of Hope Valley, SA found out recently . . .

I was asked to have a look at a TV reception problem for a friend. It turned out that he had moved into a rental property and had positioned his TV in a corner of the lounge-room diagonally opposite the built-in antenna wall socket. As a result, he was using a small, portable antenna but this really wasn't up to the job. There was a lot of interference on the analog stations and the signal strength was so poor that his digital set-top box would not lock onto any channels.

I looked outside and noticed that the house had a modern VHF/UHF antenna mounted on the roof, complete with a coax downlead. My first step was to make sure that the cable was actually connected to the wall socket, so I unscrewed the wall plate and confirmed that all was OK. I then moved the TV over to the outlet and plugged it in, at which point it started displaying perfect pictures.

As a result, I advised my friend to purchase a good-quality 75-ohm TV extension cable and run it around the room between the wall socket and his TV. This would be the cheapest solution to his problem, as the rental agreement forbade any modifications to the property.

In due course, he purchased a 10-metre 75-ohm coax extension cable from a local electronics retailer and installed it. However, when I visited him later that week, he told me that he had tried the cable but it had made the reception worse!

I didn't have any tools with me, so I was unable to troubleshoot the problem there and then. He had installed the extension cable correctly and I suggested that the most likely problem would be corrosion or an open circuit in the downlead at the antenna terminations.

When I subsequently called back with my gear, I decided to check the new cable first before climbing up on the roof to look at the antenna connections. And to my surprise, a simple check with the multimeter showed that while the screen was continuous, the centre core was open circuit!

So much for quality control – a brand-new 75-ohm TV extension cable complete with moulded connectors and the core is open circuit! How simple can it get? In 35 years of electrical/electronics work I have never before come across a problem with a new pre-terminated cable or test lead.

Mrs Bleep's new antenna

There's an old saying that no good deed goes unpunished. It might sound a bit cynical but my next story from M. S. of Niddrie, Victoria does tend to reinforce the point . . .

My 27-year-old TV antenna was on its last legs and with digital TV now available in our area, I decided to shout myself a new "digital" antenna. This was duly installed and gave excellent results on all channels.

While I was installing it, my neighbour Mrs Bleep (I call her that because she swears so much) saw what I was doing and said that she also wanted a new antenna. As a result, I told her where to purchase one plus about 7m of new coaxial cable. There was no way I was going to buy it for her because I know that she would accuse me of ripping her off, no matter what it cost.

Anyway, a few weeks went by and just when I'd assumed that she'd forgotten all about it, I got a blast from across the street . . . "when are you bleep'n putting my bleep'n new antenna up". Well, I thought that I had better mollify her, so the job was scheduled for the following weekend.

Unfortunately, things didn't quite go according to plan. With the new antenna installed, the picture was just as bad as before and Mrs Bleep was now bleep'n worse than ever. I checked and rechecked all the connections, checked the cable, adjusted the orientation of the antenna and got precisely nowhere. This was getting bleep'n frustratin'.

In the end, I decided to substitute a set of rabbit ears (ie, an indoor antenna)

Servicing Stories Wanted

We welcome reader contributions for Serviceman. If you have any good servicing stories that you would like to share, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics or electrics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to:

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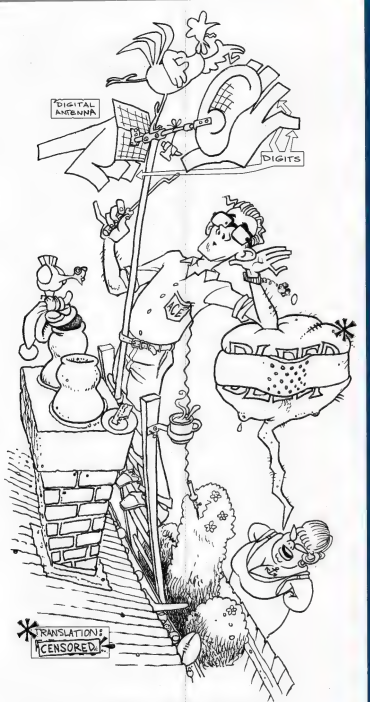

~MRS BLEEP SAW WHAT I WAS DOING & SAID THAT SHE ALSO WANTED A NEW ANTENNA...

to see if I could isolate the problem. However, when I went to plug it into the digital set-top box (STB), the plug wouldn't go in. The reason for this was simple – the original fly lead from the wall to the box was faulty and the plug at the STB end had separated from the cable and was still in the antenna socket.

I replaced the fly lead with a good quality one and the signal went from the original 30-40% to 90% plus on all channels. In fact, I suspect that Mrs Bleep's reception problems had been caused by the dodgy fly lead and that her original antenna was probably adequate.

Still, it didn't matter. Mrs Bleep has a shiny new antenna, great reception and is now bleep'n happy. SC

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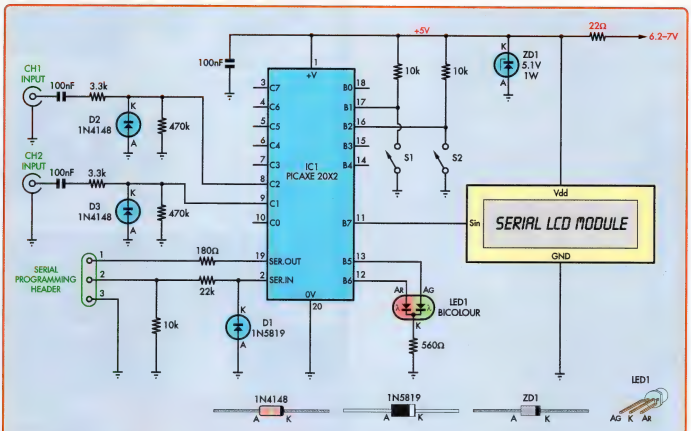
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



PICAXE-based dual frequency counter

This circuit uses a PICAXE microcontroller to measure the frequency of two different signals and displays both on an LCD panel. It has no controls since it uses auto-ranging for the two counters. The circuit was designed to be combined with a function generator based on a pair of XR2206 ICs but it can be built as a stand-alone device or as part of a different project.

Its two inputs accept TTL signals and should work with signals of around 3-6V peak-to-peak. As presented, it will measure frequencies up to 100kHz but the software can be modified to work up to at least 350kHz.

The frequencies of the two signals are alternately measured by the PICAXE 20X2 microcontroller (IC1), which runs at either 16MHz or 32MHz, as needed. The signals are AC-coupled via 100nF capacitors and then applied to inputs C2 and C1 of the micro via 3.3kΩ current-limiting resistors. Diodes D2 & D3 help clamp the signal so that their troughs are no lower than -0.7V.

Bi-colour LED1 indicates which input is currently being sampled. It turns green for input CH1 and red for input CH2.

The frequency readings (Hz, kHz, MHz, etc) are displayed separately on the two lines of an AXE033 16x2 serial LCD module. This module is available from Revolution Education, the same company that developed the PICAXE microcontroller range (**www.rev-ed.co.uk**).

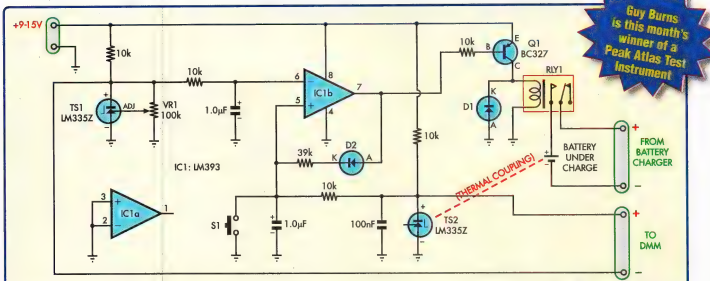
S1 and S2 were originally switches to control the function generator modulation mode so IC1 monitors their position and shows information about the mode on the LCD. If the switches are left out (but the 10kΩ pull-up resistors left in) then this feature is disabled. Otherwise, the software can be changed to monitor switches on these inputs for some other purpose.

The circuit includes a programming header for the PICAXE. Both the microcontroller and LCD module run from a 5V rail which is derived from a 6.2-7V supply using zener diode (ZD1) and a 22Ω current limiting resistor. A linear regulator (eg, 7805) or a 5V regulated supply could be used instead and would allow a wider range of supply voltages (say, 7-15V).

The PICAXE program, **DualFrequencyCounter_v1.6.bas**, is available for download from the SILICON CHIP website.

Brett Cupitt,
Port Macquarie, NSW. ($50)

Guy Burns is this month's winner of a Peak Atlas Test Instrument



Nicad/NiMH battery charge controller senses temperature rise

This circuit was designed after extensive testing with various different nickel cadmium and nickel metal hydride cells in AA and AAA sizes. The tests were designed to determine which method is best for detecting when the battery reaches full charge: the small voltage drop (-dV/dt method) or the battery's temperature rise above ambient.

Test results showed that the cell temperature spikes after it reaches full charge but before its terminal voltage begins to drop. So if the temperature sensing method is used, the cells experience less over-charging, prolonging their life. It is also a much more reliable method; if the charger fails to sense the small drop in voltage during charging (as some do), it can seriously overcharge the cells, causing damage. Many such chargers include a time-out to handle such situations but that is a poor solution.

There are two limitations to the temperature sensing method. First, if the cells have been rapidly discharged, they may be hot and should be allowed to cool down before they are recharged. Second, the charge rate must be at least 200mA and no more than C/2 (eg, 1150mA for a 2300mAh cell) to get the appropriate temperature rise.

The circuit uses two LM335Z temperature sensors, TS1 and TS2. These act like zener diodes with a reverse breakdown voltage that depends on temperature. With a bias current of 0.4-5mA, the voltage across each sensor is 10mV/°K. Since 25°C is about 298K (298.15K to be precise), the output voltage is 2.98V at room temperature and varies by 10mV for each 1°C above or below that.

TS1 measures the ambient temperature and TS2 is placed in intimate contact with the battery. When the temperature at TS2 is 5°C above the temperature at TS1, charging is terminated. Trimpot VR1 is connected to the ADJ pin of TS1 and this is used to trim TS1's output so that it is 5°C low. As a result, a simple comparator can be used to detect the end-of-charge condition.

Note that if the battery is housed and charged within an enclosure, TS1 must also be inside it to ensure that the temperature difference is measured correctly. Otherwise TS1's reading will be artificially low, causing premature charge termination.

The bias current for both sensors is supplied by a 10kΩ resistor from the +9-15V supply rail (ie, about 1-2mA to each sensor). There is an RC filter, consisting of a 10kΩ resistor and 1µF capacitor, at the output of each temperature sensor to remove any spikes. The two sensor voltages are applied to comparator IC1b. TS1's output is connected to its inverting input (pin 6) while TS2's output goes to the non-inverting input (pin 5).

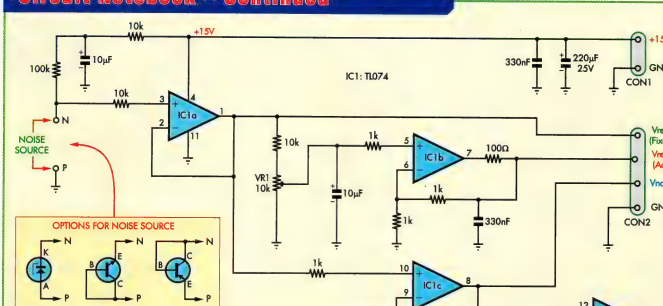
Charging starts when momentary pushbutton switch S1 is pressed, thereby connecting pin 5 of IC1b (the non-inverting input) to ground. This forces IC1b's output low, turning on PNP transistor Q1 and in turn, energising relay RLY1. This connects the battery to the charger.

Once TS2's output voltage exceeds that of TS1 (when the battery temperature is at least 5°C above ambient), IC1b's open-collector output switches off, subsequently turning off Q1 and RLY1 and thus disconnecting the battery from the charger. Diode D1 absorbs inductive spikes from RLY1's coil.

When the relay is off, current flows through Q1's base-emitter junction, the 10kΩ resistor, diode D2 and the 39kΩ resistor. This raises the voltage at pin 5 of IC1b, the non-inverting input, providing hysteresis. This prevents the relay being switched on again when the battery cools down after charging.

To correctly calibrate the charge controller, first ensure that both TS1 and TS2 are at the same temperature. They can be placed in thermal contact or just left at ambient temperature. Then connect a millivolt meter or DMM where shown, apply power and adjust VR1 to get a reading of +50mV. Ensure that the meter is connected the right way around when making this adjustment.

Guy Burns,
Ulverstone, Tas.



PN junction acts as voltage reference and noise source

Reverse biased bipolar transistor base-emitter junctions behave similarly to zener diodes and so may be used as a voltage reference. The reverse breakdown voltage of these junctions varies from transistor to transistor but is usually between 5-10V. This circuit provides an adjustable level of amplification so that it can be trimmed to a specific value and also takes advantage of the fact that reverse-biased PN junctions are noisy to provide a noise source from the same device.

This circuit can also be used in combination with an audio millivoltmeter or oscilloscope to measure the noise of various P-N junctions, in order to select the best device to use as a white-noise source. PNP transistors typically provide the highest noise levels when reverse biased.

In this circuit, a small amount of current is passed through the PN junction via a 100kΩ resistor connected to +15V. The voltage developed across the junction is buffered by IC1a, part of a TL074 quad JFET-input op amp. Its output voltage at the Vref1 terminal depends on the PN junction used.

Potentiometer VR1 allows the reference voltage from IC1a to be attenuated by a factor of two or more. IC1b then amplifies the adjusted voltage by two. The 100Ω resistor and 330nF capacitor at its output filter the resulting reference voltage, removing most of the noise. The gain of this arrangement is from zero to one (2 ÷ 2) so the Vref2 output voltage can be adjusted to be between 0V and Vref1.

Op amp IC1c amplifies the AC noise component of the signal from the PN junction by a factor of 511 to provide a higher level noise source. If necessary, the amplitude of the Vnoise output can be adjusted by changing IC1c's feedback resistors. Reducing the 51kΩ resistor will reduce the noise level.

Petre Petrov,
Sofia, Bulgaria. ($50)

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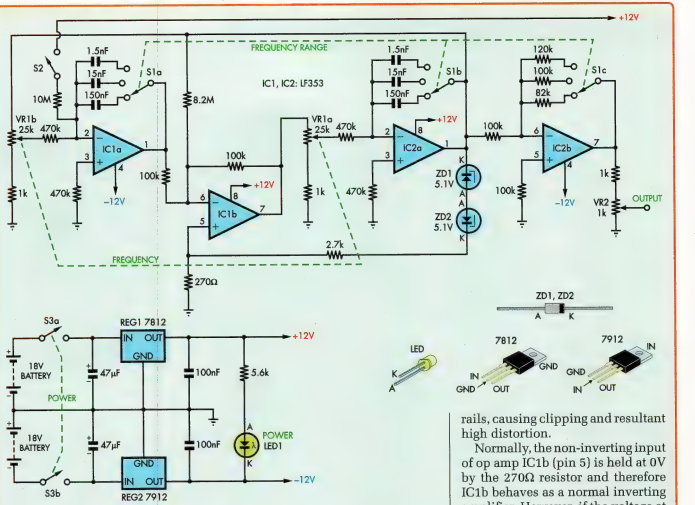


Wien bridge oscillator uses zener stabilisation

This oscillator produces low distortion sinewaves from very low to medium frequencies (0.1Hz-2kHz).

Wien bridge oscillators present two main design challenges – amplitude stabilisation and settling time – both of which are related. In this circuit, the amplitude is stabilised with a zener diode clamp and the settling time is reduced by the use of a momentary switch (S2) which, when tapped, gives the oscillator a "kick start". This is especially useful when the oscillator is running at the lower frequencies, otherwise it can take several minutes to settle.

S1, a 3-pole 3-way rotary switch selects one of three frequency ranges (the circuit is shown with the switch in the 0.1-20Hz position). The intermediate position gives a range of 1-200Hz and the third position a range of 10-2000Hz. The frequency is adjusted within the selected range by dual-gang potentiometer VR1.

The oscillator circuit itself is formed from two integrators which operate 90° out of phase. This is analogous to a swinging pendulum, in which the position, velocity and acceleration are all described by the sine function. These integrators are driven by op amps IC1a and IC2a, each of which is half of an LF353 dual JFET-input op amp (TL072s may be substituted).

Between the two integrators is op amp IC1b which is configured as an inverting amplifier. This adds 180° of phase shift, giving a total of 360°; the required condition for stable oscillation. Op amp IC2b is the output buffer. The output amplitude can be controlled with potentiometer VR2. The output impedance is relatively high (1-2kΩ, depending upon the amplitude selected).

Zener diodes ZD1 and ZD2, arranged back-to-back, limit the oscillation amplitude. Wien bridge oscillators operate with positive feedback and without some form of negative amplitude feedback, the amplitude increases until it reaches the supply rails, causing clipping and resultant high distortion.

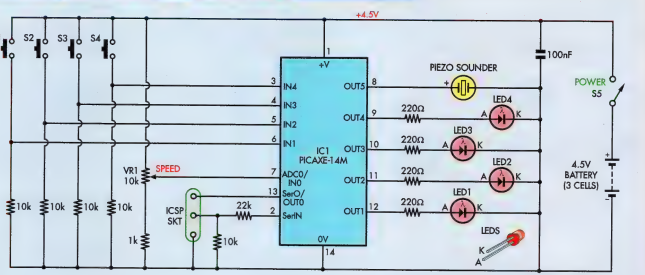
Normally, the non-inverting input of op amp IC1b (pin 5) is held at 0V by the 270Ω resistor and therefore IC1b behaves as a normal inverting amplifier. However, if the voltage at the output of op amp IC2a exceeds about ±5.7V, current flows through ZD1, ZD2 and the 2.7kΩ resistor, developing a voltage at pin 5 of IC1b.

5.7V is the reverse breakdown voltage of one zener diode plus the forward voltage of the other. The 2.7kΩ and 270Ω resistors form a voltage divider with a ratio of 11 so that this feedback is applied gradually. The feedback is negative and therefore stabilising in nature, despite the feedback being applied to the non-inverting input of IC1b. That's because the signal path between the two op amps is inverted by IC2a.

Note that the signals at pin 2 of IC2a and pin 1 of IC1a are also sinewaves. One leads the output signal by 90° and the other lags it by the same amount.

As shown, the circuit runs off a regulated ±12V supply derived from four 9V batteries in series but a 12-15V AC transformer, rectifier and filter capacitors could be used instead.

Robert Astridge
Wentworth Falls, NSW. ($60)



PICAXE version of Simon Says

This PICAXE-14M version of the Simon Says game has been adapted from the original PICAXE-18A program published in SILICON CHIP, January 2005. The conversion required changing the code from using separate code and data memory to the shared memory model of the 14M. Other sections of the code have been rewritten for better style.

The pin assignments for the inputs and outputs have also been changed to make circuit layout easier.

The game makes use of four pushbuttons, four LEDs and a piezoelectric sounder. The pushbuttons and LEDs are arranged together, in a diamond pattern.

The LEDs flash in a pseudo-random sequence, starting with two steps. The player must use the pushbuttons to mimic the sequence. Each time it is successfully replicated, the sequence is shown again but with one extra step. If an error is made, the game is over and a new game starts.

Some extra sounds and LED flashes have also been included to make the game more exciting.

Each pushbutton has an associated 10kΩ pull-down resistor and they are connected to inputs IN1-IN4 (pins 3-6). The LEDs are driven from outputs OUT1-OUT4 (pins 9-12) via 220Ω current-limiting resistors.

A potentiometer is connected to analog input ADC0 (pin 7) and this allows the game speed to be adjusted. The micro samples the voltage at this pin, from which it derives the potentiometer's rotary position.

Power is from a 4.5V battery and is controlled by power switch S5. The IC's power supply is decoupled by a 100nF capacitor. The circuit also includes an In-Circuit Serial Programming (ICSP) socket, to allow the micro to be easily reprogrammed.

The source code is available from the SILICON CHIP website (**simonsays_pgm.bas**).

Ian Robertson,
Engadine, NSW. ($50)

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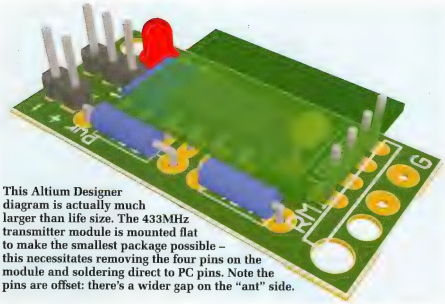
Simple, Cheap 433MHz Locator Transmitter

...perfect for use as a

- Lost model plane or rocket finder
- Stolen bike or even missing pet tracker
- Fox hunting
- and much more!

So you made last month's 433MHz "sniffer" receiver and now fancy some adventurous tracking? Here's a versatile PICAXE-08M controlled transmitter, based around Jaycar's ZW-3100 companion 433.92MHz ASK (Amplitude Shift Keying) module. While relatively short range, this transmitter makes a great model plane or model rocket locator and/or tracking beacon – something we've been asked about numerous times.

by Stan Swan



This Altium Designer diagram is actually much larger than life size. The 433MHz transmitter module is mounted flat to make the smallest package possible – this necessitates removing the four pins on the module and soldering direct to PC pins. Note the pins are offset: there's a wider gap on the "ant" side.

Using last month's "sniffer" receiver and simple wire antennas, line-of-sight (LOS) ranges of 1km have been achieved from this simple transmitter, falling to several hundred metres when light vegetation and wooden buildings obscure the propagation path.

Better receivers and antennas (perhaps a UHF scanner and Yagi) could significantly extend this range.

The transmitter module

Jaycar's "always works" ZW-3100 433MHz transmitter module has long been recommended for simple wireless data links. We've used it before for assorted wireless projects and although rated at only a few milliwatts (meaning it's not going to blister paint on nearby buildings!), this module gives a good account of itself, especially when elevated and feeding a decent antenna.

Although they're essentially a slow (300-10kbps) data transmitter, pulling the module's data line to the supply voltage via a 10kΩ resistor means capacitively-coupled audio tones can be sent instead.

Although more sophisticated and powerful 433.92MHz offerings are now appearing (and are under consideration for a possible future article), these can be very demanding to configure!

PICAXE driver

The legendary versatility of the PICAXE-08M allows beeps, simple tunes, Morse ID, or even sequential multi-tone (SMT) Hellschreiber to readily modulate the transmitter. Deep sleep periods can be included as well, greatly extending battery life – perhaps an important issue for a homing beacon.

Power supply

The transmitter module is normally rated for just a 3V supply, although some data sheets indicate 6V may be used. To remain on the safe side, we've supplied it via a 3 x AA (ie ~ 4.5V) PICAXE-switched control line.

With such a supply, under 4V will normally be on the TXC1 positive. Use of a 4 x AA holder and a dummy cell allows versatility for use of weary batteries or lower voltage rechargeable cells as well. A ~ 100mAh lithium coin cell may even be suitable but duty cycles will have to be very low to prolong battery life in this case.

The circuit shown uses about 10mA but if powered on for (say) just a few seconds every minute the average would drop to under 1mA. Alkaline cells of 2000mAh capacity may thus last hundreds of hours, translating to perhaps months of beacon service – a key benefit when trying to locate a device before batteries run flat.

Solar power could even be considered but a model plane or rocket lost in dense vegetation may naturally mean little solar charging occurs.

The method of assembly is not critical and could be built on solderless breadboard for trials, then transferred to the tiny PC board as shown here if weight and size is an issue.

A homing beacon

Googling "lost model plane" returns all manner of heartbreaking tales relating to searches for downed radio-controlled planes. These models may be worth thousands, especially FPV (First Person View) types that carry a video camera aloft.

Tall grass, crop fields and trees may so frustrate the hunt that a searcher could be within metres of the model and never find it. Flashing LEDs or alarm sounds may help but these may only be seen at night or heard in quiet locations.

However, wireless beacons can be detected at any time, provided the vegetation and terrain is not too dense. Simple radio direction finding (RDF) and triangulation can assist in the hunt.

For more professional applications GPS encoding of course may be an option but (aside from cost) the increased battery drain and weight may become an issue. A simple 433MHz "ping" beacon may save the day!

While the original intention was for a homing beacon for lost model planes and rockets, there's nothing to stop you incorporating the transmitter into a host of other devices – a pushbike, for example or perhaps even a car.

Sure, you have to get quite close before you'll start receiving a signal but believe it or not, that's more often than not the norm (especially for "pushies", which are often dumped only a few blocks away from where

It's called the "Ugly Albatross" and its claim to fame is the FPV camera mounted on the nose. It's not the sort of plane you'd be real happy about losing and our 433MHz tracker suits it perfectly.

they were stolen!).

Maybe a mercury switch could be used to trigger the transmitter – the thief is quite likely to drop the bike where he finished with it, rather than carefully standing it up as you would!

"Fox hunting"

But it's not all about hunting downed model planes and rockets. While outlining the features of the 433MHz sniffer receiver last month, its use for simple "fox hunting" was mentioned.

If this month's transmitting fox feeds a decent antenna and is elevated, then (compared with a simple quarter-wave whip antenna at or near ground level) coverage will be greatly improved.

Perhaps the best antenna for this is a "Slim JIM" (J Integrated Matching), akin to the 162MHz type outlined in the June 2009 AIS article, suitably dimensioned for 433MHz. Stick-style "JIMs" have legendary low-angle omnidirectional radiation and particularly suit horizontal applications.

At 433MHz a wavelength is only about 70cm and the Slim JIM antenna is then only about half a metre tall. No special assembly techniques are needed and light hookup or bell wire can be used for the construction. Indeed, two lengths of wire stripped from a half-metre or so of ribbon cable are ideal (and very light weight).

Part of the allure of fox hunting is tracking down and finding well-hidden or well-camouflaged transmitters.

When mounted inside a suitably coloured plastic tube offcut (or even a length of bamboo), the entire setup (including transmitter and batteries) can be hauled up to a tree branch for enhanced coverage as well as enhanced camouflage!

Beacons can be distinguished from each other by suitable encoding as well – simple beeps, ring tones or even snatches of tunes are a breeze to generate with a PICAXE.

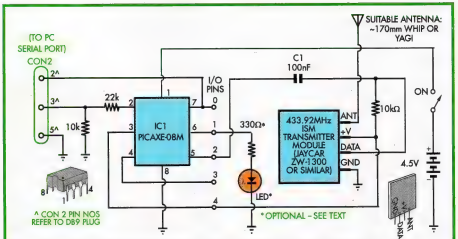
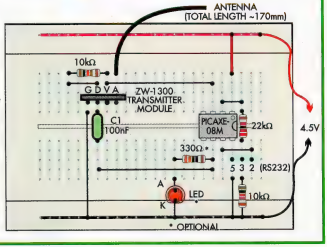


Fig.1: the PICAXE 08M, suitably programmed, not only feeds data to the transmitter module but also provides it with power from its output 4 (pin3).

Fig.2: the tiny PC board layout. It's deliberately crammed in to make the board as small as possible.

Fig.3: here's the protoboard version. Of course, there are many other ways to fit the components and links but this one is logical. The LED and 330Ω resistor are shown as optional but are perhaps more useful in this protoboard version as it is probably the one most used for experimentation.



The circuit

The circuit could hardly be simpler: a PICAXE 08M driving the Jaycar 433MHz transmitter module – and not much else! A 100nF capacitor couples the two together with a 10kΩ "pullup" resistor connecting to the transmitter module's positive supply. This in turn is driven from the PICAXE 08M, as mentioned above.

If you can justify the slight increase in current consumption, perhaps also include a LED on the transmitter board (as shown), as this will visually assist in confirming both transmitter sending and duty cycle. If every nanoamp is vital, simply leave out the LED and 330Ω series resistor. The PICAXE 08M won't care one way or the other.

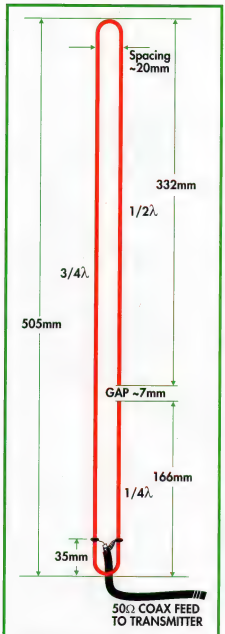
A 22kΩ and 10kΩ resistor make the connection to the serial port on your PC for programming.

Construction

While such a simple circuit lends itself to construction on Veroboard, we are not fans of such. We've found far too often that beginners, especially, make fundamental mistakes, such as not cutting tracks adequately.

We'll admit to building our first prototype on Verobard but the final project has been built on a purposely-designed PC board. While this adds slightly to the cost, the chances of even a beginner successfully constructing the project are dramatically enhanced.

The board is made deliberately tiny, in fact, everything is crammed in to



Last month we showed how to build a simple 4-element Yagi which could be used for transmitting or receiving. The famous Slim JIM antenna above, with dimensions shown for 433MHz, can also be used for both and has the added advantage of being thin and therefore highly camouflage-able! With the very low power of the transmitter, just about any wire can be used (strands from a rainbow cable would be ideal). To keep it rigid, you could glue the wire to the outside of a piece of 20mm (OD) PVC conduit which, for protection, could be slid inside a length of ~25mm (ID) conduit. By the way, the top and bottom do NOT have to be the nicely rounded shape shown here!

make it so. This is to give the best possible chance of fitting inside a model plane or rocket.

Note that the transmitter module is mounted "laid over" 90° so that it lies across several components including the PICAXE-08M. This is to minimise height – again, to help it fit.

This will require you bending the pins downwards 90° before soldering it in (note that if space is not a problem for you, it can be mounted in the normal (vertical) position.

Programming the PICAXE is almost always undertaken "in situ" so a 3-pin socket is provided to connect to the serial port on your PC. We won't go into the programming details again as we have done this extensively in the past. If you can't find the back issues of SILICON CHIP which cover the subject, you'll find plenty of information on the net (eg, see my site at the end of this article).

A simple 3-terminal programming interface can be made from a cut-down DIP8 IC socket – access this via a 3 header pins attached to a normal serial lead. A "DIP3" socket has the advantage that stiff wire will "plug in". The alternative, a 3-pin header set, will require a suitable connector. Note that once programmed, the programming connection is removed.

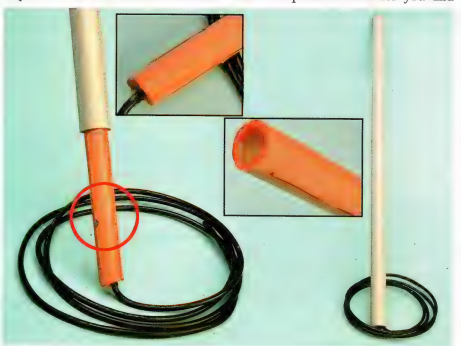
We've made provision for a pair of PC pins for power connection but if these make the PC board too high for your application (in some, every millimetre counts!) then simply wire direct to the board.

Similarly, a PC pin can be used for antenna connection. You will note another hole next to the PC pin: this is for "strain relief" on the antenna wire. If used in a model plane or rocket, vibration can be a real problem so the cable threads through these holes before attachment.

There's also another pad alongside the antenna PC pin – this is for the braid (earth) of 75 Ω coax cable if this is required for connection to an external antenna (such as the Slim JIM shown here or the Yagi shown last month).

If used, the LED can be mounted on the board or connected via flying leads so that it can poke through the plane or rocket fuselage (and so be seen externally). Choose a superbright LED for best effect (contrary to what you might think, superbright LEDs draw no more current that ordinary LEDs).

We'll leave both the battery holder and the power switch for you and



Here's the "Slim JIM" antenna we made to suit the transmitter, from the dimensions at left. Basically we hot-melt glued two fine wires to the outside of a length of 20mm conduit. Highlighted (red circle) is one of the two connections between antenna wire and 50Ω coax cable; the coax solders through holes in the conduit. Inset are two views showing the method of construction – we used hot melt glue to tack the wires in place and to seal the ends against little intruders! The right-hand photo is the completed antenna fully encased in its outer conduit, ready to connect to the transmitter (it also works fine as a receiving antenna).

```
'Simple two tone TX modulator – refer www.picaxe.orcon.net.nz/433fox.htm
DISABLEBOD          ' turns off brown out detection
TX:                 ' transmitter routine
HIGH 4              ' turns on transmitter module
HIGH 1              ' turns on TX LED
SOUND 2,(100,10,0,10,120,10)  ' 2 tone beeps modulate TX
LOW 1               ' turns off TX LED
LOW 4               ' turn off TX
SLEEP 2             ' sleep ~5 seconds (units 2.3 seconds)
GOTO TX             ' awakens & repeats routine
```

your particular application (it may be simply a matter of twisting two wires together!).

Protoboard version

OK, we give up! We know there will be many readers who would be interested in building this for experimentation but don't want to make it permanent nor go to the expense of a PC board.

Therefore, we've also shown the traditional protoboard wiring as well – the big advantage with this is that both the protoboard AND the components can be re-used (in fact, the PICAXE 08M can be re-programmed again and again).

So the choice is yours – permanent on a PC board or temporary on a protoboard. We'd still advise against the Veroboard route, though!

Mounting in a rocket or plane

There are several difficulties to overcome when mounting the transmitter PC board inside a model plane for tracking. It's arguably one of *the* most hostile places to mount any circuitry.

Fast-revving engines and vibration, high g-force turns and the inevitable "slightly harder than normal landing" (ie, a crash!) puts stresses on the components which they were never intended to suffer.

Model rockets are perhaps worse, with the enormous thrust forces on launching. For this reason, you need to make sure that construction is exemplary – stressing a PC board will very quickly test your soldering ability!

The second problem is where to mount it. There's usually not a great deal of room inside a model plane or rocket so it may need to be shoehorned in.

Wherever you place it, ensure that it is adequately secured and if possible shock-protected (many modellers use a thin piece of "foam rubber" under or even right around the PC board).

The tail area of the plane is usually the least vibration-prone area – and because planes rarely back into solid objects (like the Earth) it is often the least-damaged area in a prang.

We've provided two mounting holes near the corners of the board. These are intended for tiny cable ties to attach the board to, well, whatever you can.

If you must use screws and nuts, there is a very high chance of shorting the copper tracks so a Nylon or fibre washer should be used under the nut.

The third problem is the antenna. Most model planes simply have a long wire antenna. At 170mm long, it's not huge but once again, you need to find somewhere it can go without fouling any engine components or aircraft controls.

Ideally, it should be straight out but if this proves difficult or impossible, don't worry: snake the antenna around obstacles etc. You shouldn't notice much degradation in range. Try to keep it away from metal components if possible and if it has to "double back" on itself, perhaps add a few centimetres to the length to compensate.

Coding

A wide variety of modulating tones and duty cycles can be programmed into the PICAXE, with assorted samples shown at www.picaxe.orcon.net.nz/433fox.htm

For initial evaluation the above simple two-tone beacon may suit. Disabling the PICAXE "brown out detect" (BOD) allows microamp-level SLEEP. Without it, significantly higher snoozing currents are drawn, which increases the battery drain. The SLEEP period here is deliberately short to streamline initial setup – extend as need be.

I'd be interested in hearing of useful applications of this simple beacon circuitry and will offer to host suitable case studies and pictures at the article resource website listed above. SC

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This compact, easy to use, component analyser is like having a library of electronic info at your fingertips! It saves hours of looking up specs. Great for R&D, engineers etc. Identifies: • Diodes • Bipolar transistors • MOSFETS • JFETS • SCR's & Triacs • LEDS • Thyristors and more! **Q 2100**

Save energy around the house

SAVE 34%
2 For $30

7 Day Digital Timer

Save on your power bill by automating appliances. Each day can switch on and off up to 10 times! Random holiday mode. Count down timer for heaters & fans. **X 8018**

BARGAIN!
$11.95

Easy-Snip Scissors

Sharp stainless steel cutters designed for use with cloth, carpet, cardboard, foam & light duty cable. **T 1490**

SAVE 25%
$19

Precision Snippers

Ideal for trimming component legs. **T 2745A**

Pure Sine Wave!

SAVE $50
$219

Power 240V Appliances From Your Car Battery

Pure sine wave 12V inverter with high 1000W surge rating suitable for powering items with switchmode power supplies or sensitive devices such as medical gear, laptops etc. Delivers clean 240VAC power via dual power outlets. 300W rated. Beware of cheaper versions with lower surge ratings! **M 8012**

20% OFF!

Compact & Stylish 19" Rack Cases

Superb quality finish. Tough powdercoated finish with raw (silver) or black anodised aluminium front. Rear panel is aluminium for easy drilling.

Type	Part	Normally	Now...
1U Raw	H 5011	$49	$39
2U Raw	H 5012	$59	$47
1U Black	H 5031	$55	$44
2U Black	H 5032	$65	$52
3U Black	H 5033	$79	$62

SAVE 15%
$42

3 Channel Energy Meter

This wireless home energy monitor can log power usage on up to 3 mains outlets around the house. Includes channel 1 plug in sensor & base station. 30m range. Displays usage in kW/h or currency. **P 8137**

Channel 2 Transmitter	P 8138	$24.95
Channel 3 Transmitter	P 8139	$24.95

Top Quality Audio Gear

$269 SAVE $30

Great performance & value for money!

Redback® 2 Channel UHF Wireless Mic Systems

Provides up to 50m wireless freedom for announcing, lectures, meetings etc. Ideal for function centres, restaurants, sporting clubs & pubs. Microphones require 2xAA batteries. 804.74 / 808.875MHz.

C 8881 - 2 handheld mics. **C 8882 - Handheld mic & Beltpack mic**

$145 NEW MODEL

Weighs just 480g including batteries!

Hands Free Mini PA System

Straps to your waist for an instant sound system. Great for addressing small crowds without the need to shout. • Includes headset, batteries and charger • iPod®/Aux input • Up to 8 hours use from a single charge • Great for promotions & live demonstrations. **C 7120**

20% OFF 19" Rack Systems

• **Australian made** • **Quick assembly!**

Build your own rack system and save! Simply select the frame, panel set and perspex door combination you need.

Rack Frames

Unit Height	Part	Normally	Now...
9U	H 5509A	$226	$180
12U	H 5512A	$252	$200
15U	H 5515A	$270	$215
18U	H 5518A	$295	$230

Panel Sets

Unit Height	Part	Normally	Now...
9U	H 5609	$159	$125
12U	H 5612	$195	$155
15U	H 5615	$210	$165
18U	H 5618	$225	$180

Perspex Doors

Unit Height	Part	Normally	Now...
9U	H 5709A	$215	$170
12U	H 5712A	$239	$190
15U	H 5715A	$250	$200
18U	H 5718A	$285	$225

Redback® 3 Pin XLR Leads

UP TO 25% OFF. Balanced 3 pin XLR male to female mic leads.

Length	Part	Normally	Now...
0.5m	P 0726	$10.95	$9
1m	P 0728	$11.95	$10
3m	P 0729	$13.95	$11
5m	P 0732	$15.95	$13
10m	P 0735	$19.95	$15
15m	P 0736	$25.95	$20
20m	P 0737	$29.95	$22

SAVE $20 $99

Fine Tune Your Sound System

A useful tool for high end home theatre systems, PA & car audio. This quality SPL meter measures up to 130dB (1.5dB accuracy). Great for live venues, installers, pubs etc. Used widely in the audio industry for ensuring sound levels remain legal. Includes 9V battery.

Q 1264

Also available in rectangular in-wall versions

SAVE $50 $169

30W Two-Way Ceiling Speakers

Expand your audio system with these professional flush mount speakers. Look and sound fantastic! Install yourself, no expertise required. Sold in pairs. 165mm (6.5"). **C 0873**

Ideal for travelling

SAVE $20 $79

Noise Cancelling Headphones

High performance noise cancelling circuitry cuts up to 20dB of exterior noise! Great for the plane or bus. Folding design. Includes batteries. **C 9018**

SAVE 20% $40

A real time saver!

"Roadies" Cable Tester

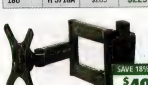
Tests 12 types of leads for continuity.

Tests: 3.5/6.35mm jack, DIN (3/5/7/8 pin), RCA, XLR (3/5 pin), S-Video. Speakon & banana leads. Requires 9V battery. **Q 2021**

SAVE $50 $99/pr

30W Two-Way Wall Speakers

Ideal for the games room, patio or alfresco area! Wall mount bracket makes installation a breeze. Aluminium grills. 130x105x170mm. 1.8kg. Sold in pairs. **C 0900 White, C 0901 Black**



SAVE 18% $49

Swing Arm Monitor Bracket

Extends up to 335mm from the mounting surface. Ultra slimline design. 20° ball joint for tilt adjustment. Suits monitors up to 24". 100x100mm VESA mount. **H 8181A**

SAVE 22% $19

Wireless FM Audio Transmitter

Transmits audio from any MP3 player to your car stereo. Car power adaptor included. 4 channels 107.1-107.9MHz FM band. **X 0600A**

Great for subwoofers!

SAVE 22% $15

Hum Loop/Noise Eliminator

Ensures a clean hum free signal on any stereo RCA line. Prevents induced interference on long leads. Simple in-line connection. **C 9555**

A 3021A 2 Way SAVE 24% $15

A 3026A 4 Way SAVE 25% $26

Dynalink® Speaker Switchers

Simple and effective way of selecting speaker zones. Maintains safe amplifier load. Sturdy steel casing. No power required!

Ultra Slim Monitor Bracket

Just 14mm deep! Mount small TVs & monitors to a wall or cabinet. 75/100mm mounting holes. 15kg max. **H 8189**

SAVE 20% $19.95

Get More For Your Dollar

SAVE $20

$89

PRICE BREAK-THROUGH!

0 Lux	420 line resolution	20m Infra-Red Range

Vandal Resistant IR Dome Camera

- Tough diecast enclosure • Low noise picture
- M 9272A plugpack to suit $17.95. **S 9115C**

SAVE $30

$95

IP66 Weatherproof

0 Lux	420 line resolution	20m Infra-Red Range

All-Weather Bullet CCD Camera

- Fully sealed metal enclosure • Day/night
- M 9272A plugpack to suit $17.95. **S 9138A**

SAVE $20

$89

Just 3cm long!

0.5 Lux	Mirrored video output	Easy to install

Compact Car Reversing Camera

- CMOS sensor • Fits easily into a number plate recess • IP65 • 12-15V DC. **S 9131**

SAVE 18%

$49

Record CCTV Footage To Your PC!

- Records 4 video channels & 2 audio channels to your hard drive. • Includes 'EZ-Cap' software
- 704x576 recording resolution • Motion detect & schedule recording • MPEG4. **S 9479A**

SAVE $20

$89

Composite To VGA Converter

Connect a CCTV system to a PC monitor! Displays a composite signal up to high resolution, 'flicker free', SXGA 1280x1024. BNC input, DE15 VGA output. Requires M 9274A 12VDC plugpack $25.25. **S 9290**

Protect Your Home & Family Today!

8 Zone Alarm System For Home Or Business

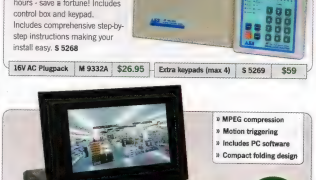
A quality professional alarm system at an affordable price. Can be fully installed and programmed by YOU in just hours - save a fortune! Includes control box and keypad. Includes comprehensive step-by-step instructions making your install easy. **S 5268**

Pick up all your alarm accessories at Altronics

$169

SAVE $30

16V AC Plugpack	M 9332A	$26.95	Extra keypads (max 4)	S 5269	$59



- » MPEG compression
- » Motion triggering
- » Includes PC software
- » Compact folding design

$399

SAVE $100

All In One Surveillance Recording Solution

4 Channel DVR With 7" Folding LCD Monitor

Provides switching, quad processing and recording functions all in one. Records up to 4 cameras (at 25 frames per second max) to an internal hard drive - available separately. • USB PC connection • Schedule & alarm event recording • Includes power supply & software for Win XP/7. **S 9331**

1TB Hard Drive	
D 5513	$99

SAVE 17%

$52

100 million possible entry codes!

Waterproof Keycode Access Pad

- Multi user 4 digit entry code system
- 3 outputs; 5A NC/NO for door strike & 2 x 1A for alarm triggers • 12VDC powered (M 9267A $22.95). **S 5372**

SAVE 16%

$90

Great Value

PIR Movement Sensors

5 year warranty! A reliable high performance passive infra red detector for alarm systems. Adjustable pick up range. Size: 100x60x40mm. **S 5314A**

SAVE 23%

$80

Also available in 6 core (W 2370)

4 Core Security Install Cable

For connecting alarm sensors such as PIR's and detectors. Full 100m pullboxes only. 14/0.20 x 4. **W 2364**

SAVE 12%

$44

Elsema® Keyring Remote Control

- 27Mhz suitable for gates, garage doors etc • Encodable via DIP switch • 100m range • Includes battery. **A 1016**

Project Part Savings

Great for automotive wiring.

SAVE 14%

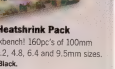
$17

Handy 160 Piece Heatshrink Pack

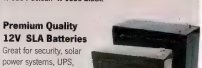
A must have for the workbench! 160pc's of 100mm heatshrink in 1.6, 2.4, 3.2, 4.8, 6.4 and 9.5mm sizes. **W 0884 Colour. W 0886 Black.**

Premium Quality 12V SLA Batteries

Great for security, solar power systems, UPS, comms gear etc..



Capacity	Part	Normally	Now..	Or 2 For..
1.3Ah	S 5075B	$19.95	$18	$30
3.3Ah	S 5080	$29.80	$27	$40
4.5Ah	S 5084	$28.90	$26	$48
7.2Ah	S 5090B	$34.95	$30	$52

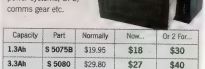


HALF PRICE!

4 For $10

HALF PRICE Flanged Heatsinks

55L x 102W x 25.2Hmm. Black anodised. **H 0568**



SAVE 28%

4 For $10

Bargain Heavy Duty Heatsinks

43L x 110W x 33Hmm. Black Anodised. **H 0560A**

SAVE 15%

2 For $10

"Missile" Toggle Switch Covers

Prevents accidental activation. Suits S 1040-2, S 1050-2, switches. **S 1036 Red. S 1037 Carbon look.**

SAVE 27%

$24

SAVE 27%

$29

Prototyping Breadboards

Build experimental circuit designs with ease. Great for hobbyists and electronics designers. Aluminium base. **P 1012A 1660 Hole. P 1015A 2309 Hole.**

DIY Project Ideas...

NEW KIT!
$199
Ideal for research & development

Dual Tracking 0-19V Power Supply Kit

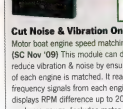
(SC June '10) Delivers up to 1.6A from positive & negative outputs with a range of ±0-19V • Adjustable current limiting • Fixed 5V 750mA output for digital logic ICs and microcontrollers. • Low noise and ripple • Load regulation 0.1%. **K 3218**

Add on a K 1108 USB interface for control from your PC - $39.95

$60 SAVE 14%

Build It Yourself Robotic Arm Kit - No Soldering Required!

A great introduction to basic robotics! Includes five motors allowing base rotation, shoulder, elbow and wrist motion, plus claw for picking up objects (up to 120g). Includes wired controller. Add on the K 1108 USB interface for control from your PC ($39.95). **K 1107**



SAVE 38%
$30

Cut Noise & Vibration On Boats.

Motor boat engine speed matching kit **(SC Nov '09)** This module can dramatically reduce vibration & noise by ensuring the RPM of each engine is matched. It reads the frequency signals from each engine tacho & displays RPM difference up to 200RPM on an analogue gauge. Includes meter. **K 6220**

SAVE $20
$129

Take The Guess Work Out Of Fixing Your Car!

(SC Feb '10). This car interpreter kit connects to your laptop and provides real time readouts from a multitude of engine sensors (in vehicles fitted with OBD II port). Ideal for mechanics & car enthusiasts. May require a RS232 to USB converter, D 2340B $29.95. **K 4065**

SAVE 15%
$75

Digital Audio Oscillator Kit

(SC June '09) Adjustable 10Hz to 30kHz output in sine, square, triangle and sawtooth waveforms for testing amplifiers, speakers and other audio devices. Three ranges: 20mV, 200mV & 1V. Requires 9V battery. **K 2543**

Great Deals On Popular Kits

SAVE 20%
$60

Cut Office Power Consumption

USB Mains Sensing Switch Kit.
(SC January '09) Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices! **K 2920**

SAVE 20%
$40

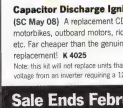
Portable PIC Programmer Kit

(SC Sept. '03) This battery powered programmer kit is suitable for: PIC16F and 12F, 16F87X series, 24CXX EEPROMS. Includes: ZIF socket, cables and 16F84 PIC chip. **K 9505**

SAVE 20%
$39

2x20W 12V Amplifier Kit

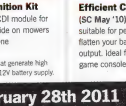
(SC May '10) This compact stereo amp module puts out 2x20W RMS into 4Ω and is powered by a 12V source (such as a SLA battery). Distortion typically <0.03%. Bass & treble controls. **K 5136**



SAVE 20%
$15.95

Capacitor Discharge Ignition Kit

(SC May 08) A replacement CDI module for motorbikes, outboard motors, ride on mowers etc. Far cheaper than the genuine replacement! **K 4025**
Note: this kit will not replace units that generate high voltage from an inverter requiring a 12V battery supply.

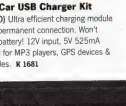


Also ideal for motorbikes

SAVE 20%
$23

Efficient Car USB Charger Kit

(SC May '10) Ultra efficient charging module suitable for permanent connection. Won't flatten your battery! 12V input. 5V 525mA output. Ideal for MP3 players, GPS devices & game consoles. **K 1681**



SAVE 15%
$20

Line Level to Balanced Signal Converter Kit

(SC June '08) Allows you to send line level signals over long distances with minimal hum and noise. Requires 9-30VDC. Size: 103x85mm. **K 5522**

Sale Ends February 28th 2011

Altronics One-Stop Electronic Shops Phone 1300 797 007 Fax 1300 789 777

Mail Orders: C/- P.O. Box 8350 Perth Business Centre, W.A. 6849

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Resellers:

WESTERN AUSTRALIA		
Bunbury	ML Communications	9721 9800
Esperance	Esperance Communications	9071 3344
Geraldton	ML Communications	9965 7555
VICTORIA		
Alexandra	Alexandra Air Con & Appliance Centre	5772 1147
Ballan	Radcomp	5368 1761
Beaconsfield	Electronic Connections	9768 9420
Benalla	North East Electronics	5762 2710
Castlemaine	Top End Technology	5472 1700
Clayton	Rockby Electronics	9562 8559
Cranbourne	Bourne Electronics	5996 2755
Croydon	Truscott's Electronic World	9723 3890
Geelong	Academy TV Australia	5248 2621
Geelong	Music Workshop	5221 5844
Healesville	Amazon DVDs Healesville	5962 2763
Horsham	Leading Edge Electronics	5382 4150
Leongatha	Gardner Electronics	5662 3891
Melton	Melton Electronics & Communications	9743 1233
Nunawading	Semitronics	9873 3555
Pakenham	Get Smart Hifi	5941 4885
Preston	Preston Electronics	9484 0191
San Remo	Shorelec Electrical Wholesalers	5678 5361
Somerville	AVPC	5978 0007
Swan Hill	Lateral Communications	5032 2322
Warrnambool	Koroit St Electronics	5561 5111
Wodonga	Exact Computers & Home Ent.	6056 5746
QUEENSLAND		
Airlie Beach	Plaza Electronics	4946 5550
Brisbane South	Delsound	3397 8155
Brisbane North	Prime Electronics	3252 7466
Capalaba	Diggy Technology	3245 0000
Cairns	Pentacom	4032 1710
Cloncurry	Access Electronics	4742 2590
Dalby	Camera House	4662 3228
Gold Coast	Prime Electronics	5531 2599
Hervey Bay	Leading Edge Electronics	4124 1490
Innisfail	Leading Edge Electronics	4061 6214
Kingaroy	SB Computers	4160 4800
Longreach	Access Electronics	4658 0500
Maryborough	Leading Edge Electronics	4121 4559
Mossman	Leading Edge Electronics	4098 2200
Rockhampton North	Home Delivered Computers	4926 2555
Rockhampton South	Access Electronics	4922 1058
Toowoomba	Access Electronics	4632 5990
Townsville	Solex	4771 4211
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NEW SOUTH WALES		
Brookvale	Brookvale Electrical Distributors	9938 4299
Carlingford	Carlingford Music Centre	9873 2333
Cessnock	Leading Edge Electronics	4990 5971
Cobar	Cobar Electronics	6836 2962
Deniliquin	Wired Entertainment	5881 3555
Gloucester	Autolec Gloucester	6558 1600
Grafton	Downes Electronics	6642 1911
Griffith	Griffith Systems Plus	6964 5933
Gunnedah		6742 2119
Lithgow	Leading Edge Electronics	6352 3333
Mudgee	Home & Office Electronics	6372 1822
Nth Richmond	CPT-Candle Power Technologies	4571 4699
Oak Flats	Oak Flats Electronics	4256 6126
Orange	Fordays Electronics	6362 9901
Penrith	Penrith Light and Sound	4733 3333
Port Macquarie	Fetsel Communications Pty Ltd	6581 1341
Raymond Terrace	Leading Edge Electronics	4987 4699
Smithfield		9609 7218
Tamworth	Bourke Street Electronics	6766 4664
Taree	Noeledge Systems Pty Ltd	6551 3622
Ulladulla	Leading Edge Electronics	4454 5588
Wagga Wagga	Wagga Car Radio & Hi-Fi Pty Ltd	6925 6111
Waterloo	Herkes Electrical Supplies	9319 3133
Wetherill Park	Techtron Electronics Pty Ltd	9604 9710
Windang	Mad Electronics	4297 7373
Wyong	CCRV - Pro Disc	4353 1100
SOUTH AUSTRALIA		
Adelaide	Aztronics	8212 8212
Berri	Gardners Berri Radio & TV	8582 1766
Brighton	Force Electronics	8377 0512
Enfield	Aztronics	8349 6340
Findon	Force Electronics	8347 1188
Kadina	Wellsecured	8821 2900
Mt Barker	Force Electronics	8391 1133
Milton	Leading Edge Electronics	8682 4911
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Universal USB Data Logger; Pt.3

In this third and final article on the USB Data Logger, we describe how to use the accompanying Windows host software. This software allows you to edit and test scripts, upload them to the logger and change its settings.

By MAURO GRASSI

AS EXPLAINED previously, scripts are used tell the Data Logger which sensor(s) are attached, how to query them, what the readings mean, how often to log the data and the data format to use.

If you have not already prepared a memory card, you can format it with a FAT or FAT32 file system (a quick format is OK) before plugging it into the Data Logger, with the power off. Having installed the host software and driver (see Pt.2), plug the Data Logger into your PC and launch the software by double-clicking the *.exe* file.

What the software does

Essentially, the Windows host software is a "development environment" which allows you to write scripts, upload them to the Data Logger and test them. It also allows you to monitor scripts as they run and download logged data over the USB interface. In addition, you can change the Data Logger's settings from the host software.

Since complex scripts can be difficult to debug when running on the Data Logger itself, the software allows you to "simulate" the scripts, running them on the host PC to see what they do. Scripts can be simulated at an accelerated rate which is useful for those scripts which involve long delays. Note that because simulated scripts are run on the host PC, they can not access the sensors as they can on the Data Logger. For example, if a simulated script reads from an analog input, the result is always zero.

User interface

The interface for the Windows-based host software is shown in Fig.11. When plugged into a USB port, the Data Logger is detected automatically. Its firmware version and the connection status are shown in the window title bar, at top.

The main window has a number of sub-windows. The script editor sub-window is at upper left and this is where scripts can be created or modified. The log sub-window below it allows you to keep track of program actions as they take place. There are some buttons between the two which clear the log window and perform other common actions.

At lower right is the console sub-window, which has a grey background. It allows you to see what a script is logging as it runs or is simulated, which is useful for testing complex scripts (more on that later). Above the console are several buttons, used to control the simulation.

At far upper right are the Data Logger settings and below them the Host Settings, which apply to the PC host software.

To the left of the settings are four additional sub-windows (two red, two green) which allow you to see the files and scripts stored on the Data Logger and on your host computer (respectively). They also allow you to manage scripts, including transferring them to and from the Data Logger.

Settings

The device settings (at upper right of Fig.11) are stored on the Data Logger, both in a file on the memory card and in its internal FLASH memory. If the file on the memory card becomes corrupted or the card is removed, the Logger relies on its internally stored settings. Otherwise, the settings on the memory card are used.

You can copy the settings between the Data Logger and the host PC via the Host and Device menus. It is also

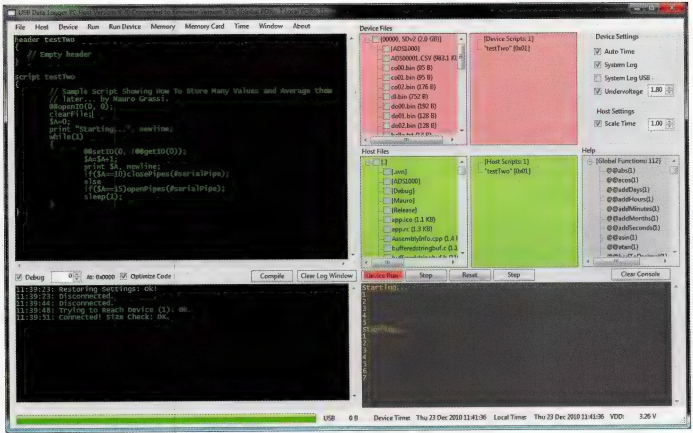

Fig.11: this is the user interface for the PC host software. This lets you edit, compile and upload scripts to the USB Data Logger via the USB interface. It also allows you to change settings and to download log files.

possible to restore the settings to the defaults using these menus. They work as follows:

Auto Time: when enabled, the PC host automatically sets the real-time clock in the Data Logger whenever they are connected. Without this option you can synchronise the time manually via the "Time" menu.

System Log: when enabled, the Data Logger will note special events in a log file on the memory card (*syslog.txt*). This is useful for troubleshooting but slows the Data Logger down and increases its power consumption. The contents of this file can be read or cleared through the host software via the Device menu when the Data Logger is plugged in.

System Log USB: when enabled, as well as logging to the "*syslog.txt*" file on the memory card, the Data Logger also sends system log messages over the USB serial interface and the host software diplays them in the console sub-window.

Undervoltage: when this is enabled and the battery voltage drops below the specified level, the Data Logger goes into sleep mode, minimising power consumption. This is recommended in order to avoid over-discharging the battery. Remember that this voltage does not take into account the voltage drop across the Schottky diode from the battery (the default setting is 1.8V as shown).

Editor window

You can use any text editor you like to write scripts but for convenience, the host software has a built-in editor, allowing small script changes to be made and then immediately simulated or uploaded to the Data Logger for testing. The script is shown in the upper left window and most of the associated commands are located in the "File" menu above it. The editor font size can be changed via the "Window" menu to provide the best legibility with your display.

If you are using a third-party text editor, the easiest way to upload the script is to paste it into the text editor window and then proceed from there.

File browser

As mentioned, the two red and two green sub-windows towards the upper right are the file and script browsers. The red windows show directories, log files and scripts on the Data Logger while the green windows show the same information for the host computer. Using these windows, you can browse the contents of both devices and transfer files between the two.

In each case the left-most window

Where To Buy Kits & PC Boards

A complete kit of parts for the USB Data Logger is being produced by Altronics and should be available shortly after this issue appears.

In addition, readers will be able to purchase the PC board from Silicon Chip. This board is double sided, with plated through-holes and features a solder mask, FR-4 fibreglass substrate, tinning and 1oz copper tracks.

The PC boards are available for $A25 (including GST) plus $A10 postage per order. Postage is $A12 to NZ or $A18 elsewhere.

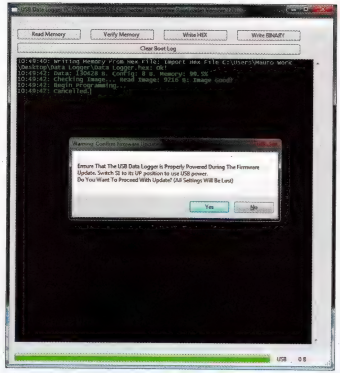

Fig.12: this interface appears if the PC host software is launched with the bootloader running. This then allows you to update the firmware in the USB Data Logger.

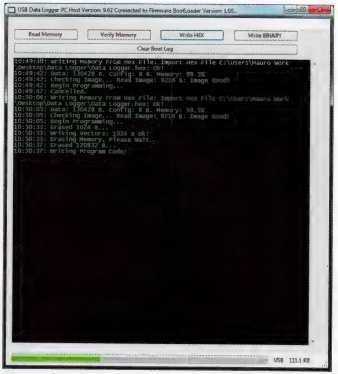

Fig.13: after selecting a hex file and clicking "Yes" (see Fig.12), the new firmware is uploaded to the logger and a progress bar is displayed at the bottom of the window.

shows the file system directory structure and files (including log files) while the right-most window shows the loaded scripts (more on that later). Up to eight script files at a time can be loaded on the Data Logger and each is assigned a unique number, which is also shown.

Local files are stored in the same directory as the host software. In both cases, the file lists are sorted alphabetically. Directories are shown in square brackets and directories and files can be opened by double-clicking them. Scripts are opened in the editor window. Right-clicking on a file gives a context menu with additional options. This includes options to initiate file transfers between the Data Logger and host PC.

Note that while this is a very convenient way to access log files on the Data Logger, for large log files (15MB or more) it can be faster to remove the memory card from the Data Logger and use a USB card reader to transfer them instead. This is because the Data Logger's USB transfer speed is limited by the PIC18F2753's small amount of RAM (Random Access Memory) and modest clock speed.

Compiling scripts

Before a script can be tested or used, it must be loaded into the editor window and then compiled. When it is compiled, the software checks that the script is valid. If there is anything wrong with it, the Compile button turns red, one or more error entries appear in the log window and compilation is aborted.

If errors are reported, the first invalid line in the script code is highlighted. The location of the error is also shown in the log sub-window, as a line and column reference. Once the problem has been fixed, you can attempt to compile the script again.

The compiler can also generate "warnings". As with errors, these are noted in the log sub-window but they do not prevent successful compilation. If present, these warnings indicate possible errors in the script but they can sometimes appear when the script is correct.

If the script is correct (ie, there are no errors), the Compile button turns green and the script is added to the list of available local scripts.

Rather than pressing the "Compile" button you can also press the F10 key on your keyboard. The compiled script can be transferred to the USB Data Logger by right-clicking on it in the green "Host Scripts" window and selecting "Send PC Script". For convenience, you can press F11 instead which compiles the script and then automatically sends it to the Data Logger, assuming the compilation was successful. You can also send all local scripts to the USB Data Logger by pressing Shift+F11.

There is a handy help window at the right of the user interface (with a grey background) which lists all defined constants, global functions and global variables in the script. Each global function is listed with a number in parentheses indicating the number of arguments that the global function takes. Global define constants are shown with their values, while global variables are shown with their size.

The "Optimize Code" option, above the log window, is enabled by default. This allows the compiler to remove any redundant portions of the script or simplify it where possible. This reduces the memory and processing required to run a script on the USB Data Logger.

Simulating scripts

Once a script is compiled, it can be simulated in the console sub-window (lower right of Fig.11) using the Run, Stop, Reset and Step buttons. Pressing Run begins the simulation and the script output is shown in the console

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window (this would normally be stored in the log file on the memory card). If you click Stop, the script pauses and the next line about to be executed is highlighted in the editor window.

You can then use the Step button to proceed through the script, one line at a time. This is good for debugging since you can observe the program flow and see the log output from each individual line in the script. The Reset button can be used to start the script from scratch and the Clear Console button blanks the console sub-window.

During simulation, the Scale Time option can be adjusted (upper right) to change the speed at which the simulation runs. For example, if Scale Time is enabled and set to 10, a scripted delay of 25 seconds actually takes 2.5 seconds. This makes debugging scripts with long logging periods far less tedious.

You can also use the console sub-window to observe data being logged to the memory card in the Data Logger as it occurs. This is useful for the final test of a script, with the actual sensors attached.

Status bar

The status bar, at the bottom of the window, indicates what the host software is doing at any given time. This shows USB data transfers, the time from the Data Logger and so on. At the right of the status bar are two flexible displays which can show various statistics, which are selected by clicking on that portion of the status bar.

The first (left-most) flexible display shows information about time synchronisation while the second shows various voltages from the Data Logger, including the supply and battery voltages.

Updating the firmware

The Data Logger's firmware (the software running on the microcontroller) can be updated from the host computer over USB. To do this, first you must activate the bootloader by holding down S2 on the USB Data Logger while applying power (normally from USB). To do this, the battery must be removed as there is no way to switch it off.

With the bootloader activated and the Data Logger plugged into the host PC via the USB port, launching the host software will display the bootloader interface instead of the usual development environment (see Fig.12).

In bootloader mode, the blue LED (LED3) flashes at around 1Hz. Once the USB interface has been recognised, the flash rate increases slightly and is faster again when the firmware is being read or written.

Typically, firmware updates are supplied as a hex file (.hex file extension). You can then use the "Write HEX" option to transfer this file's contents contents into the microcontroller's FLASH memory (Fig.13). It will check that the file is valid, then ask you to confirm that you want to overwrite the existing firmware. After rewriting the program memory, a verify operation is automatically performed to ensure that it was successful.

Note that if you subsequently use the Data Logger and then attempt to verify the firmware manually using the Verify Memory button, the verification will fail because the Data Logger also uses the FLASH memory to store its settings. This also means that updating the firmware resets the Data Logger's settings to its defaults.

Using the logger

When operating, pushbutton S2 and blue LED3 are used to control logging and provide feedback. A short press of S2 tells you the logging status: LED3 will flash once if at least one script is running or three times if there are no scripts running (and therefore no logging is taking place).

A longer press of S2 pauses all scripts, in which case the logger flashes its LED three times to confirm that logging is paused. A second long press results in a single flash and logging resumes.

The blue LED also flashes to indicate USB activity when the USB interface is in use by the host software.

Standby mode

The logger automatically goes into standby mode under the following circumstances:

(1) When there are no custom scripts loaded.

(2) When all the custom scripts that are loaded are paused or not running.

(3) When there is a time delay of at least five seconds, during which no custom scripts need to run.

(4) When the under-voltage protection is enabled and the battery voltage is below the set threshold.

In standby mode, the Data Logger's USB interface shuts down (the PC host will show it as being "disconnected") and the LED glows dimly but does not flash.

As mentioned in Pt.1 (December 2010), the full power savings will not be made unless the minimum logging period of all executing scripts is above the threshold for going into standby (five seconds). Below this threshold, the microcontroller does not switch off power to certain components, including the memory card, because otherwise the initialisation sequence would take too long. You will therefore get the best battery life if your logging scripts execute sleep periods of greater than or equal to this time.

In standby mode, the current drain from the battery is around 560-850µA. If the battery voltage is very low, the PIC enters sleep mode which is at the

Tips For Installing The USB Driver

Here's a tip for installing the USB driver. The USB Data Logger will go into standby (and detach from the host PC's USB interface) when there are no custom scripts loaded. This is done to save power and since initially there are no scripts loaded, this will be the state of the USB Data Logger after it is first switched on.

As this can affect the installation of the driver (since the USB connection may be lost during the driver installation), it is advisable to install the driver with no memory card inserted in the socket. When switched on, if no memory card is present, the USB Data Logger does not enter standby as quickly as it does when a card is present.

This gives you around two minutes to plug it in and install the driver, which should be long enough in most cases. If not, you can always press S2 to keep it out of standby for another five seconds. This feature is provided as a fail-safe feature in case the USB Data Logger is used with a very old system.

Sample Excerpt From Syslog.txt

```
Time Unavailable: USB Data Logger Version: 9.60. Global PORs: 4. Local PORs: 1.
Time Unavailable: Memory Card Detected, Total Size: 2.0 GB Free Size: 2.0 GB.
Time Unavailable: VM(s) Running: 1 of 2.
Time Unavailable: The Following VM(s) Are Loaded: { oneScript, csvScript }
```

lower end of this range (560µA) and it stays in sleep mode until the device is power cycled.

This does not include the current consumed by any sensors powered from the Data Logger. Typically, sensors will not consume much power when they are idle but for long-term logging, even a small amount of additional power can reduce battery life.

If the Data Logger goes into standby mode while plugged into USB, it will disconnect from the host PC (it won't do this if the host program is running). Pressing S2 or inserting a memory card brings the Data Logger out of standby mode.

While writing to the SD card, instantaneous power consumption from the battery can be 25mA or more but if the scripts have long sleep periods, this averages out to a much lower value in the long term.

System log

As mentioned earlier, the Data Logger can store events in a system log for troubleshooting purposes. A sample excerpt from the *syslog.txt* file, as created when the Data Logger is switched on, is shown in the accompanying panel.

The first line shows the Data Logger firmware version and the number of power cycles (Power On Resets or PORs) that the USB Data Logger has undergone. The Global reading indicates full resets while the local reading shows the number of times the scripts have been reset by the software. This can happen if the memory card is removed.

The second line shows information on the memory card while the third shows how many virtual machines (VMs) are actively running scripts (there are up to eight). The fourth line shows the names of the scripts that are loaded.

Here are some more example system log entries:

```
Thu 23 Dec 2010 05:42:01: Destroy 2 VM(s).
Thu 23 Dec 2010 05:42:11: Holding.
```

The first line indicates that two scripts were reset, resulting in their virtual machines being "Destroyed". The second indicates that script execution has been paused by a long press on pushbutton S2.

Digital sensor requirements

When using an input for frequency or event counting, you must make sure the signal is within 0-5V (for D0-D3) or 0-3.6V (for D4 & D5).

For I²C sensors, their SCL (clock) line must be connected to D0 and the SDA (data) line to D1. While the pin connections for the I²C bus are fixed, multiple scripts can access sensors on the one bus.

One Wire sensors can connect to any of the six digital pins D0-D5. You must configure the correct pin number in the script. The same applies to the serial port; you specify the Transmit and Receive pin numbers, the baud rate and the mode. The serial port supports baud rates up to 0.5Mbps.

Multiplexed peripherals

While the PIC18F27J53 microcontroller has just two serial peripherals, each of the eight possible scripts can configure its own serial port with whatever configuration it requires (pin connections, baud rate, etc). The PIC's peripheral pin select (PPS) feature allows the software to re-map the UARTs as appropriate for each script as it runs. This is the same feature which allows One Wire sensors to be connected to any of the I/O pins.

For example, you can have one custom script sending data to a serial port on pin D0 at 9600bps, while having another script sending data to an independent serial port on pin D1 at 115,200bps. The hardware state is saved and changed as required by the firmware for the currently executing custom script.

As well as selecting the pin connections and baud rate for the serial port, scripts can choose to invert the receive or transmit logic or to have an open drain output.

Writing scripts

Finally, for those who build the USB Data Logger, we have prepared some detailed information on writing logging scripts, including a complete description of the language's syntax and global functions and variables.

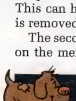
This information is available as a PDF file from the February 2010 section of the SILICON CHIP website. It is named "USB Data Logger User Manual.pdf". SC

Errata

To improve filtering of the +3.3V supply rail, the 22µF tantalum capacitor on the output of REG1 should be changed to a 220µF 10V low-ESR electrolytic (Jaycar RE-6300). This change applies to both the circuit diagram in Pt.1 (December 2010, page 38) and to the overlay diagram in Pt.2 (January 2011, page 35).

Note that there are two 22µF tantalum capacitors shown adjacent to REG1 on the overlay. The capacitor on the left is the one to change.

The parts list in Pt.1 should be amended accordingly.



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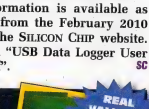
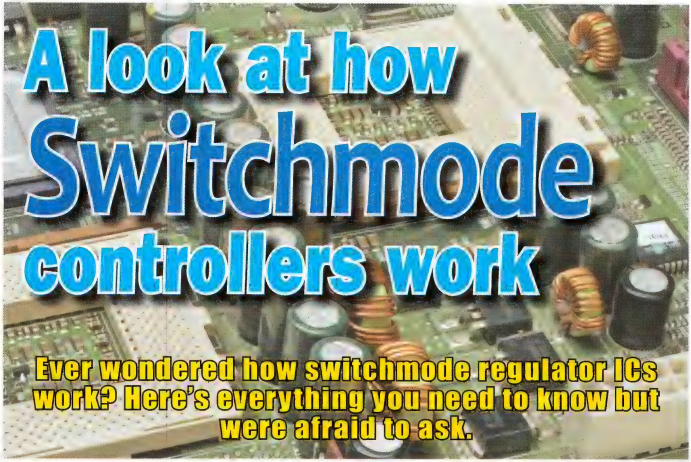




A look at how Switchmode controllers work

Ever wondered how switchmode regulator ICs work? Here's everything you need to know but were afraid to ask.

By NICHOLAS VINEN

ELSEWHERE IN THIS ISSUE, we present the LED Dazzler, a 10W LED driver that uses switchmode regulation to control its output current. During the course of its design, we initially spent quite some time working on circuits based on a common switchmode controller IC, the UC3843 (or TL3843).

There are significant advantages in using a controller IC such as the UC3843. You can use virtually any switching topology such as buck, boost, buck/boost, boost-buck, Cuk, SEPIC etc. The switching frequency, frequency response, current limit and other parameters can be customised to suit the application.

Because you choose the switching devices and their configuration, it is possible to build a regulator that will deliver a lot of current (10A or more) or one which can handle high voltages, rather than being restricted to the specifications of a particular integrated regulator.

But while the UC3843-series datasheet contains all the information necessary to understand its inner workings and thus build a circuit around it, the authors assume that the reader is fully familiar with the operation of switchmode regulators.

Switchmode basics

The main point to consider for any switching regulator is that the output voltage is typically controlled by the duty cycle of a Mosfet. The Mosfet is turned on and off rapidly and its duty cycle varies the output voltage because it determines the ratio of switch on-time to off-time.

The majority of switchmode regulators use a fixed frequency pulse width modulation (PWM) scheme. Others use a scheme where either the on-time or off-time is fixed and the other varies. Both methods allow control of the duty cycle but with the latter type, the frequency also varies.

Fig.1 shows the functional block diagram of a typical switchmode controller IC (modelled on the UC3843), used here as part of a boost regulator.

For boost regulators, with the switch off (ie, 0% duty cycle), the output voltage (Vout) is one diode drop below the input voltage (Vin). As the duty cycle increases, so does the output voltage. The practical upper limit depends on the load impedance but is generally around three to four times the input voltage.

In short, when the switch is on, current flows from the input supply through the inductor and Mosfet and then to ground, and this stores energy in the inductor's magnetic field. During this time, the diode (D1) is reverse biased, so load current is supplied by the output capacitor (C2).

When the switch turns off, the inductor's magnetic field collapses and the energy stored in it is fed via the diode to charge the output capacitor.

Basic controller operation

Let's look at the big picture first. The IC's internal oscillator (centre) generates a fixed frequency square wave. This sets the latch and, via the AND gate, drives a transis-

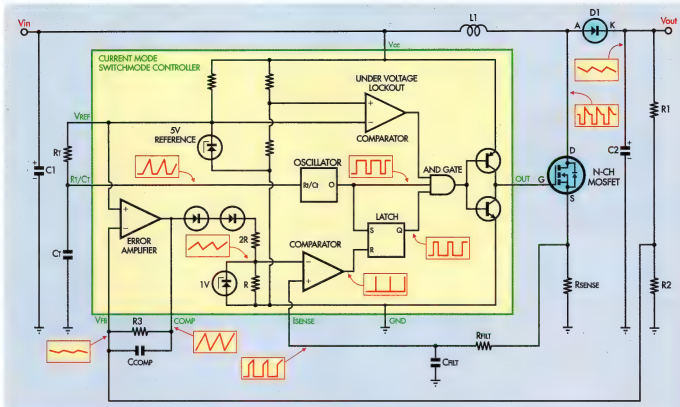
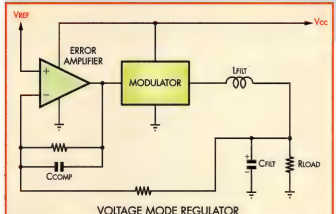
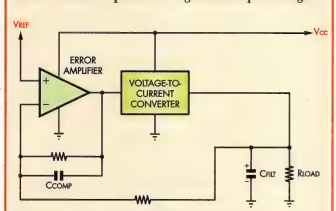


Fig.1: block diagram of a typical switchmode controller IC. It is shown here controlling a boost regulator circuit based on L1, D1 and an N-channel Mosfet.



VOLTAGE MODE REGULATOR

Fig.2(a): simplified representation of a voltage mode regulator. The error amplifier drives a modulator to dervice a pulse width modulated (PWM) signal which is then filtered to produce a regulated output voltage.



CURRENT MODE REGULATOR

Fig.2(b): in this circuit, the modulator and inductor are replaced with a voltage-to-current converter. This eliminates the inductor from the feedback loop, improving the regulator's transient response.

tor buffer that in turn drives the external Mosfet. In each cycle, the latch is reset at a point determined by voltage feedback (via VFB) and current feedback (via ISENSE). The later it is reset during each timing interval, the higher the duty cycle. The feedback voltage at the VFB pin is amplified by the error amplifier and then compared with the current feedback at ISENSE in order to determine when the latch is reset.

The controller also includes a reference voltage which is used as an input to the error amplifier and also to provide the "under-voltage lockout" feature.

Feedback loop

The simplest switchmode regulator operates in "voltage mode", whereby the difference between the output voltage and the target voltage is amplified and filtered to determine the switch duty cycle. As the output voltage drops, the output of the error amplifier increases, driving the duty cycle up in order to compensate. Similarly, if the output voltage is too high, the duty cycle is decreased.

Refer to Fig.2(a) for a simplified representation of a voltage mode regulator. The error amplifier drives the "modulator" which presents a square wave to the LC output filter by alternately switching its output between Vcc and ground. The duty cycle of this square wave is determined by the voltage at the error amplifier output.

The main problem with this scheme is that there are three poles in the regulator's frequency response. So what is a "pole"? Many readers will be familiar with the -3dB point of a low-pass filter. This is an example of a "pole". For frequencies above that -3dB point (ie, pole) the response

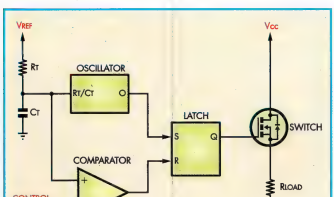


Fig.3(a): block diagram of a modulator circuit. This controls the Mosfet switch using PWM, with the duty cycle determined by the control voltage input.

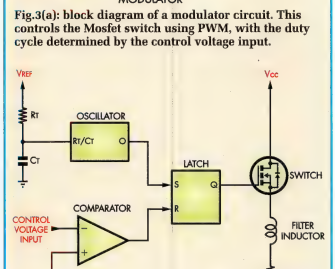


Fig.3(b): the voltage-to-current circuit is similar to the modulator, the difference being that the control voltage now determines the average current through the load.

of a low-pass filter drops off at a fixed rate.

Of the three poles in the regulator circuit, two are from the LC (inductor/capacitor) output filter and one is from the compensation capacitor (CCOMP). Multiple poles mean a faster roll-off in the frequency response and this reduces the ability to compensate for sudden supply voltage or load transients.

This situation is improved by the use of "current mode" regulation, which is the most common method used these days. By regulating the current being delivered to the output capacitor, rather than the voltage across it, the inductor's pole is eliminated from the frequency response. Essentially, the inductor and controller together can then be considered as a variable current source.

As shown in Fig.2(b), the modulator and inductor are replaced with a voltage-to-current converter, the inner workings of which are not shown. The filter is therefore just the output capacitor, which has one less pole than the LC filter that the voltage mode regulator uses.

This results in better load regulation. The current feedback path includes an RC filter (RFILT and CFILT) to remove switching spikes. This adds a new pole but its corner frequency is high so it has little impact on load regulation.

Another advantage of a current-mode regulator is that pulse-by-pulse current limiting is easy. If the output is short circuited, the inductor can quickly saturate, reducing its effective inductance and leading to excessive current being drawn from the input power supply. Since a current-mode regulator controls the current directly, the switch turns off early in such a situation.

We can implement the voltage-to-current converter roughly as shown in Fig.3(b). This shows how the control voltage input determines the current through RLOAD. The current through RLOAD is converted to a voltage by RSENSE and fed to the comparator.

The oscillator periodically turns the latch on, allowing current to increase through the load. As it does, the voltage across RSENSE increases. When this exceeds the control voltage, the latch is reset and the switch turns off. The current through the load then drops, until the next timing cycle.

As can be seen from Fig.3(a) & Fig.3(b), the voltage-to-current converter is quite similar to the modulator, adding just a few components (such as a current sense resistor) and incorporating the inductor. Once the complete circuit is drawn, both regulation methods involve similar components and differ only in the details of the feedback network.

Current-mode regulation

Essentially, current-mode regulation (as shown in Fig.1) works as follows. Voltage feedback is provided to the VFB pin of the controller via a resistive divider composed of R1 and R2. These are chosen so that the voltage at the VFB pin equals the reference voltage VREF (in this case 5V) when the correct output voltage level is reached.

The difference between this feedback voltage and the reference voltage is amplified by the error amplifier. Since the error amplifier is inverting, its gain is set by external resistor R3 in combination with feedback resistors R1 and R2. The compensation capacitor CCOMP, which rolls off the voltage feedback response for stability, is connected in parallel with R3.

The amplifier's output voltage is attenuated and then applied to the inverting input of the comparator which controls the latch. Its non-inverting input is connected to the filtered voltage from the current sense resistor at the ISENSE pin. With this configuration, either an increase in output voltage or switch current will cause the comparator to reset the latch, reducing duty cycle.

In practice, what happens is that over longer periods (as determined by the compensation arrangement), it is the output of the error amplifier that controls the switch duty cycle. Over shorter periods, because CCOMP limits the error amplifier's rate of change, the duty cycle varies in order to keep a consistent peak current through RSENSE.

Since a change in load current affects how much energy is left in the inductor's magnetic field for the next pulse, this will have an almost immediate effect on the ISENSE voltage. This in turn causes a quick change in the duty cycle to compensate, keeping a relatively constant amount

of energy stored in the inductor at the end of each pulse.

At the same time, the load transient has an effect on the output voltage and eventually CCOMP's charge will change enough to cause some feedback, returning the output voltage to its correct level after the transient.

Logically, this method results in superior regulation but it brings additional challenges. With current mode regulation, the duty cycle is inherently unstable when it goes above 50% unless slope compensation is used. Luckily, this is pretty easy to implement, as is explained later.

For in-depth information on current mode regulation, see the following document: **http://www.venable.biz/tp-05.pdf**

Controller details

The oscillator which controls the switching frequency is similar to a 555 timer but it requires just one resistor (RT) and one capacitor (CT) to set the frequency and duty cycle.

Capacitor CT is charged from a reference voltage (in this case VREF, 5V) via RT, until its voltage reaches a threshold relative to VREF. During this time, the output of the oscillator is high. Once the threshold is reached, the oscillator's output goes low and CT is discharged by a current sink. This means that the discharge time is controlled mainly by the value of capacitor CT.

So CT is chosen to give the desired off-time and then RT is chosen to give the desired on-time. The sum of these times is the timer period and this determines its frequency.

The AND gate between the latch and output transistors allows switching to be disabled when the under-voltage lockout is in effect. It also ensures that the output is off during the oscillator discharge cycle, limiting the maximum duty cycle (which is necessary in some applications).

In this example, the output of the AND gate controls a push-pull transistor pair which is suitable for driving a Mosfet gate. Some switchmode controllers have open collector outputs instead, for driving bipolar transistors. In some cases, there are two outputs that switch alternately to drive a transformer.

The under-voltage lockout circuit works by dividing the supply voltage down and comparing it to the output of the internal voltage reference. Not shown is the comparator hysteresis. Typically, the voltage reference is connected to an external pin and can be used for other purposes too.

The diodes at the output of the error amplifier allow the error amplifier to operate in linear mode when the inverting input to the comparator is at 0V. If the amplifier's output reaches ground, it is subject to a recovery delay. This is most likely when a load transient causes the output voltage to spike.

These diodes, in combination with the R/2R resistive divider, convert the wide swing of the error amplifier into a level between 0V and 1V (clamped by the zener diode at the comparator's input). This matches the 0-1V range at the ISENSE pin.

Rsense is chosen so that 1V is developed across it with the maximum allowable inductor current. If ever this is exceeded, because the inverting input of the comparator is clamped to a maximum of 1V, the switch will always turn off.

Component selection

Knowing how the controller IC works, you can design a circuit around it. However, selecting the component values can be difficult.

Consider the feedback voltage divider comprising R1 and R2. The resistor ratio required is determine by the ratio between the desired output voltage and the IC's reference voltage (VREF) but the values chosen also depend on the regulator's minimum load requirement.

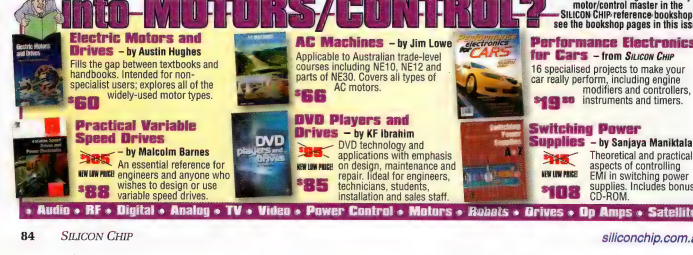
Normally R2 is in the range of 1-5kΩ. This means the feedback divider will draw 1-5mA from the output (since VREF = 5V and VFB is regulated to VREF). If a higher value is used for R2, the output voltage could rise above the target level with little or no external load (eg, due to leakage through D1).

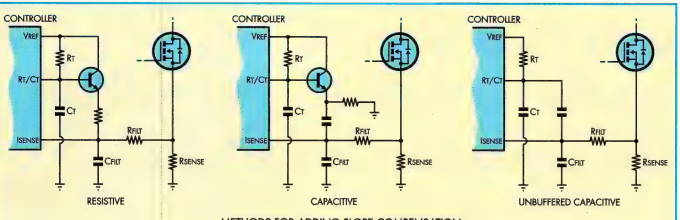
The maximum duty cycle chosen depends on the regulator topology (boost, buck, etc), the maximum load current and the ratio of maximum output voltage to minimum input voltage. Once these are known, a value for CT can be determined.

L1 and C2 are usually chosen once the switching frequency is known (as set by RT and CT). Normally, the time constant of the L1/C2 filter is set to no more than 1/6th of the switching frequency otherwise excessive duty cycle hunting can occur, resulting in sub-harmonic oscillation.

Larger values for L1 and C2 generally result in reduced output voltage ripple but also worse load regulation. Large value inductors can be bulky, heavy and expensive. So for less ripple generally a larger capacitor (or several in parallel) is used.

In high-current applications, a value of RSENSE which develops 1V may be impractical due to the required dis-





METHODS FOR ADDING SLOPE COMPENSATION

Fig.4: slope compensation is necessary to ensure stability in a PWM current-mode regulator operating at high duty cycles. It involves coupling a ramp waveform into the feedback path and can be implemented in several different ways.

sipation, so an amplifier can be inserted between it and the ISENSE pin (with RFILT/CFILT in its feedback network). This will introduce a delay, however, reducing the regulator's phase margin and requiring increased compensation.

The values for RFILT/CFILT are generally chosen for a corner frequency somewhat above the switching frequency.

C1 should be as large as practical, in order to reduce current spikes through the supply wiring leading to the regulator. The remaining components to select are R3 and CCOMP, which determine the error amplifier gain and compensation.

The error amplifier's closed loop gain affects the regulator's overall open loop gain. A higher overall open loop gain leads to better voltage regulation at the output but also must be rolled off at a lower frequency in order to ensure stability. Essentially, the higher the open loop gain, the less the permitted change in output voltage with load variations.

Say the output voltage is 12V, with a feedback divider ratio of 2.4:1. A 24mV deviation in VOUT results in a 10mV deviation in VFB. If the error amplifier gain is 300, this results in a 1V swing at the comparator's inverting input and therefore the regulator will vary the switching current between zero and the current limit. This suggests that a reasonable gain figure is of the order of 100.

The open loop gain must fall below one at a frequency where the regulator phase shift is below 360° or else the system will become unstable. Calculating the exact phase shift of a regulator is a difficult and complicated task which involves analysing the properties of both the regulator and the filter components.

If you are not well versed in feedback theory, the value for CCOMP can be determined empirically by increasing it until the regulator proves to be stable to load transients across the expected range of input voltages. However, this can be time-consuming. To select an initial value, calculate the value for CCOMP so that its impedance at one fifth the regulator's switching frequency is no higher than R2's.

Slope compensation

As mentioned earlier, current-mode regulators which can achieve duty cycles over 50% require slope compensation for stability. Slope compensation involves adding a ramp signal into the feedback path, such that the current level required to turn off the switch drops towards the end of each pulse.

Because the oscillator generates a sawtooth waveform at the RT/CT pin, we can use this for slope compensation. As recommended in the UC3843 datasheet, an NPN emitter-follower can be used to buffer this ramp waveform. The output of that amplifier is then resistively summed into the ISENSE feedback path. This compensation method (along with some other possibilities) is shown in Fig.4.

This has the effect of raising the current feedback voltage later in each pulse and therefore resetting the latch earlier than it otherwise would be. In our LED driver project, we used capacitative coupling to inject the ramp signal into the feedback path. This has the advantage of removing the timing ramp's DC offset from the slope compensation signal.

In fact, our LED driver avoids the transistor buffer because the coupling capacitor is so small that it barely affects the oscillator frequency. No matter how the slope compensation is achieved, it helps to stabilise the duty cycle by providing some negative feedback. If the correct level of compensation is applied, hunting is kept to a low level across the entire duty-cycle range.

An alternative to slope compensation is to use a fixed off-time scheme. This solves the same problems but does not need to be tuned for maximum effectiveness, as the slope compensation does.

Conclusion

Switchmode regulators are very common today, especially in battery-powered systems and devices such as computers, where multiple voltage rails are required. While the mathematics of regulator theory is daunting, design can be approached using a process of trial and error.

A breadboard can be used for experimentation as long as the current involved is kept low (say, less than 1A). The only special components required are the controller IC, a Mosfet, a Schottky diode and an inductor. A good collection of resistors and capacitors is useful if you want to experiment with various compensation and gain settings.

A controller IC and a handful of components can form the basis of a powerful and efficient DC/DC converter as long as the feedback loop is set up correctly. SC

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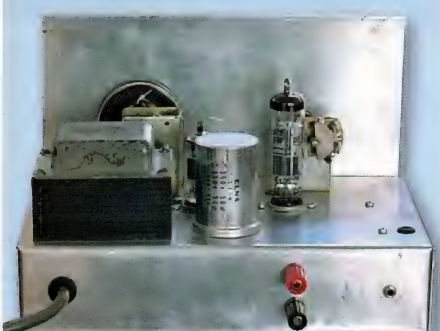
02/11

By RODNEY CHAMPNESS, VK3UG

Building the best 2-3 valve radio receiver

Almost every year, the Vintage Radio Club of North East Victoria runs a competition called the "Hellier Award". The challenge is to build an item of equipment, usually a radio receiver, to see who can produce the best result.



Eric's 1967 All-Wave-Two was built on a simple folded aluminium chassis and is neatly laid out. The addition of a "band-spreading" capacitor in parallel with the main tuning gang should make tuning a breeze.

THE PROJECTS FOR the Hellier Award are designed to stretch members' abilities and this year's project was to produce a 2-valve radio receiver. What made this a challenge was that each valve could have more than one active device in the one envelope. Valves such as the 6BL8, which has both pentode and triode sections, could be used or going even further, a 12-pin Compactron valve such as a 6AF11 could be pressed into service.

The 6AF11 incorporates two triodes and a pentode in the one envelope, so just imagine the sort of set that could be built using a couple of Compactrons – if you could obtain them.

If the set was to be mains-operated, then the rectifier valve was excluded from the valve count. In addition, the set could be a broadcast-band or multi-band unit, it could be housed in a suitable cabinet and it could have either loudspeaker or headphone output or both. Both superhet and tuned radio frequency (TRF) receivers were eligible for the 2010 competition.

Unfortunately, a few members ran out of time to produce a suitable entry, including yours truly. In the end, four members came up with workable sets, all of them TRF receivers.

One receiver was a variant of the "1955 Miniature DXer" while another was based on the "1958 Basic Three", both originally described in "Radio & Hobbies" (the forerunner of "Electronics Australia" magazine). The other two sets were based on the "1967 All-Wave-Two" from "Electronics Australia".

Only one entrant (Dennis) built a cabinet, which made his entry complete and he was also judged the winner. Dennis's cabinet is based on the "Aristocrat 3", circa 1931.

As can be seen from the photographs, the construction techniques used varied somewhat. We'll look at each set in turn a little later on.

The 1967 All-Wave-Two

This little TRF receiver was originally published in "Electronics Australia" in June 1967. It has some interesting design features that overcome some of the limitations of a regenerative TRF receiver, with the first stage functioning as both an RF amplifier and a detector.

A common problem in most TRF sets occurs because antennas are a complex combination of inductance, capacitance and resistance. In combination with the RF coil, this combination gives rise to a number of resonances across the tuned frequency range, especially in multi-band receivers which cover from 500kHz to

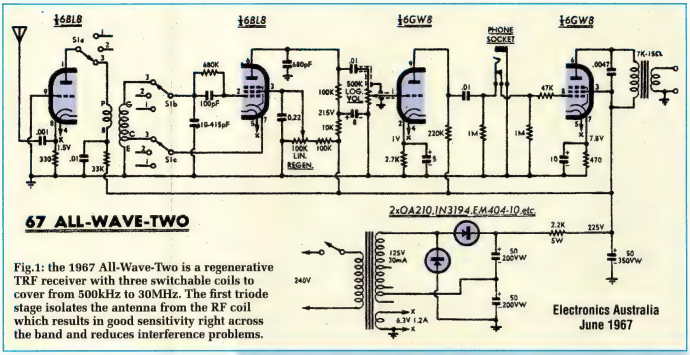


Fig.1: the 1967 All-Wave-Two is a regenerative TRF receiver with three switchable coils to cover from 500kHz to 30MHz. The first triode stage isolates the antenna from the RF coil which results in good sensitivity right across the band and reduces interference problems.

Electronics Australia June 1967

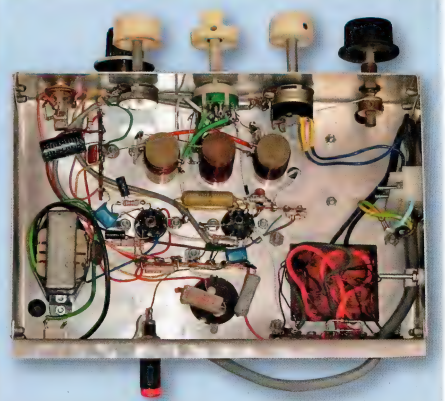
30MHz. The effect is to desensitise the front-end circuitry at these resonant frequencies.

This is due to the regenerated signal being "absorbed" by the antenna (which acts as a tuned circuit at some frequencies). As a result, it may not be possible to adjust the receiver so that it is just shy of going into oscillation, thus significantly reducing the gain.

This problem was overcome in the 1967 All-Wave-Two by using a triode to isolate the antenna – see Fig.1. This triode stage very effectively isolates the switched RF coil from the antenna circuit (more on this shortly).

As a bonus, this feature also makes life much easier for people listening to sets nearby. When the receiver is being used to listen to Morse code or single sideband (SSB) transmissions on shortwave, the detector circuit must be oscillating. In most sets, this injects a signal into the antenna which is then radiated (ie, the set acts as a transmitter). This signal then interferes with other receivers tuned to the same frequency nearby.

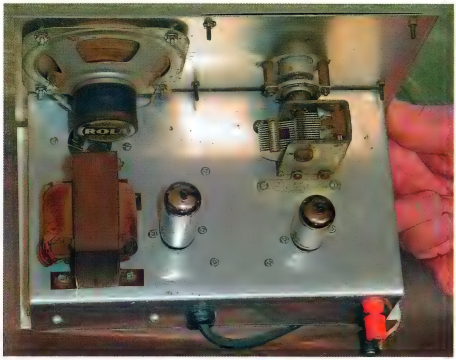
However, because the antenna is well isolated in the 1967 All-Wave-Two, that problem does not arise in this design. As shown in Fig.1, the first valve in this receiver is a 6BL8 or a 6U8. Its triode section is connected as a grounded-grid amplifier and the antenna is connected to the cathode. The output is taken from the plate as normal.



The three tuning coils in Eric's set are quite close together, so there may be some problems with mutual inductance upsetting the performance. All parts are readily accessible for servicing.

This configuration doesn't provide much gain but what it does do is to make the characteristics of the antenna relatively unimportant. It effectively smooths the operation of the regeneration on each band and reduces any radiation from the detector when it is oscillating.

By contrast, nearby receivers tuned to the same frequency are likely to receive interference if the regenerative detector is the first stage of a receiver



This photo shows the above-chassis views of David's version of the 1967 All-Wave-Two. It closely resembles the original "Electronics Australia" design.

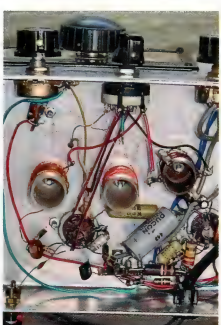
(as in most other TRF designs). However, after looking at this part of the circuit, I wonder whether the gain of the stage could be increased by inserting a small RF choke in series with the 330Ω cathode resistor. This resistor places a fairly heavy load on the antenna signals and isolating these signals from ground with a small RF choke could be worth a try.

The pentode section of the valve is used as a regenerative detector. Instead of having a tertiary winding for regeneration, the tuned winding is configured as a Hartley oscillator. The screen voltage is varied to control the gain of this stage and hence the point at which oscillation occurs.

This method obviates the need for a variable capacitor (eg, 100pF) regeneration control. These are now hard to come by and in any case, are more expensive than a carbon-track potentiometer.

The RF stage has three tuned coils and these are switched by a 3-pole, 3-position switch. As stated in the original article, these tuning coils must be carefully positioned, otherwise the mutual coupling between them (if great enough) can create sensitivity problems in some sections of the frequency band.

The audio amplifier is conventional and uses a 6GW8 triode-pentode. This stage then drives a loudspeaker via a transformer and there is more than enough gain for most stations to be heard at good volume.



The coils are more widely spaced in David's set, leading to less interaction between them. The set performs quite well.

The power supply uses a mains transformer with a 125V secondary. This feeds two silicon diode rectifiers which are wired as a simple voltage doubler to derive a 225V HT (high tension) supply. Two 50μF 200V electrolytic provide the necessary filtering for this HT rail, while a 6.3V winding on the transformer feeds the valve heaters.

In summary, the 1967 All-Wave-Two is a good choice for this project. It is a simple design with band-switching to cover from 500kHz to 30MHz. It also has high gain and due to the carefully-designed front-end, is much more docile to use than many other regenerative receivers.

Eric's 1967 All-Wave-Two

Unfortunately, Eric didn't quite get his version of this receiver finished, so it can be considered a work in progress. And like most of the other entrants, he hasn't yet built a cabinet to house the chassis.

The chassis and front panel were both made out of aluminium sheet. The chassis was bent to suit and the edges riveted, while the holes for the valve sockets were made using a hole punch. The cut-out for the power transformer was made using a nibbling tool.

Most of the other holes in the chassis were drilled and these are fitted with rubber grommets where appropriate, to protect the wiring insulation. In a few cases though, the edges of the holes were simply chamfered to make sure no damage could be done.

Considerable care has been taken to ensure that no mains wires or terminals are exposed within the receiver. The cable is clamped and is sheathed with heatshrink tubing on all terminations, including on the on-off switch/volume control pot.

The layout of the coils is reasonably critical to avoid mutual inductance problems, as occurred to some extent in the original receiver described in "Electronics Australia". What happens is that the distributed capacitance of an unused coil resonates on a frequency that's covered by the next coil up the band. As a result, some of the energy in the selected coil at this frequency is coupled into the unused coil and this significantly reduces the performance.

In this receiver, provided the coupling between the two coils is not excessive, the problem can be overcome simply by advancing the regeneration control further than normal at the affected frequencies. However, if the detector cannot be brought into oscillation by the regeneration control, then it's necessary to modify the coil layout to solve the problem.

In fact, the original article offers a few suggestions to reduce the coil inter-coupling problem, including metal shielding and orientating the 2-8MHz coil at right angles to the other two coils. Taken together, these two techniques should virtually eliminate the problem.

In Eric's set, the under-chassis wiring is laid out so as to provide easy access to all valve pins. This makes it easier to troubleshoot the circuit later on, should it become necessary. However, the tuning coils are quite close together, so he may experience some of the problems referred to above. The speaker is mounted externally, which is different to the layout of the original.

Eric also added a low-value variable capacitor in parallel with the main tuning gang. This technique is called "band spreading" and makes it easier to tune single sideband (SSB) and Morse code transmissions on shortwave. Band spreading was a common technique in amateur radio receivers during the home-built era.

Unfortunately, Eric ran out of time with this set. The dial scales had not been completed by the judging deadline and the control shafts were also still at full length. In addition, on the day of judging, the set threw a "hissy" fit and refused to work when the speaker transformer decided it had had enough and the primary winding shorted to the frame.

Apparently the speaker had become disconnected whilst the output was at high volume. As a result, high voltages were developed across the speaker transformer primary and the insulation broke down because there was no load on the transformer.

It's a pity that Eric had not been able to complete the set by judging day, as its ability to easily tune SSB would have been interesting. Tuning SSB voice transmissions on shortwave is not usually easy with simple TRF receivers and Eric's band spread modification should make a big difference in this regard.

David's 1967 All-Wave-Two

David's receiver was also built on an aluminium chassis. Like Eric, he bent the chassis himself but instead of riveting it together, it is secured with self-tapping screws. The front panel has been rubbed down with steel wool and the finish looks good.

In fact, David's set more closely resembles the original set shown in "Electronics Australia". He hasn't made a cabinet for it but this will have to be done at some stage in the near future, if only to protect the user from dangerous voltages under the chassis.

David's 1967 All-Wave-Two closely resembles the original "Electronics Australia" design. A cabinet will be necessary to protect the user from high voltages under the chassis

The power transformer is mounted above the chassis and is secured in place using four screws. The mains cord is clamped with a through-hole cordgrip grommet and the chassis securely earthed.

The coils in David's set are more widely spaced than in Eric's receiver and so any interaction between them should be inconsequential. Basically, David has closely followed the original design when it comes to the component layout. As a result, the parts are a little crowded around the audio amplifier.

Once the set was performing satisfactorily, the dial scale was calibrated. The resulting receiver works quite well.

Ray's Basic Three 1958

"Radio & Hobbies" magazine (the forerunner of "Electronics Australia") occasionally described receivers that used valves that were older in vintage than those commonly in use at the time and the "Basic Three 1958" is one such receiver. The circuit is basically the same as that for the "Miniature DXer" of 1955. However, Ray's Basic Three uses a 6SJ7GT and a 6V6GT instead of the 6AU6 and 6BV7 valves used in the "Miniature DXer".

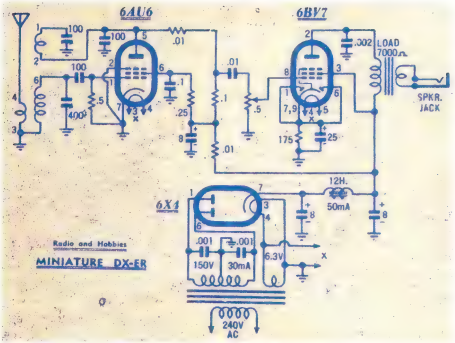
Most 2-valve regenerative receivers with just two active stages are almost identical to each other. In fact, it isn't hard to find your way around the circuit without a circuit diagram, although a diagram does makes working on a set somewhat easier.

As can be seen in the photographs, Ray's entry is not conventional in presentation. It is built more like a display item, with the valves, controls, major components, speaker and transformers all mounted on one flat sheet. No part of the receiver is mounted on the wooden surround. The oval-shaped loudspeaker faces upwards and is protected by perforated aluminium mesh which covers two large round holes directly in front of the cone.

Unlike the other entries, the mains input to this receiver is via a male IEC socket. All the exposed mains terminations have been covered with heatshrink tubing to ensure safety and the mains wires have been secured with cable ties. The wiring is neat, with easy access to all the valve and coil pins at their respective sockets.

The first stage uses five plug-in tuned coils to cover from 500kHz to 32MHz, with generous overlapping of each range. Each of these coils was wound onto PVC tubing, which was then glued onto an octal plug. The coils are inserted as required into a

Ray's 1958 Basic Three is built like a display item, with the major parts clearly labelled. It uses five plug-in coils to cover from 500kHz to 32MHz



The circuit used by Ray is basically the same as that for the "Miniature DXer" of 1955 (also used by Dennis for his set). However, Ray's set uses a 6SJ7GT and a 6V6GT instead of the 6AU6 and 6BV7 valves shown here.

matching octal valve socket on the top of the chassis.

There are three windings on each coil assembly – the antenna coil, the tuned winding and the regeneration winding (also known as the reaction or tickler winding). The 6SJ7 valve is wired as a conventional regenerative detector.

Normally, an RF choke is wired into the HT feed to the plate of the detector to prevent RF from being passed to the following stage. However, an RF choke is not used in this instance as any inductor will have a resonant frequency or multiple resonant frequencies across the receiver's tuning range of 500kHz to 32MHz.

As a result, a 10kΩ resistor has been used instead and on the broadcast band, at around 530kHz, this has a greater resistance to RF signals than a 2.5mH RF choke.

The power supply uses a transformer that Ray wound on a lathe. One possible problem is that the speaker transformer is quite close to the power transformer. This is risky, since the power transformer can induce hum into the speaker transformer that no amount of filtering will eliminate. However, it looks as though Ray has been fortunate in this set, as there is no obvious hum.

One deviation from the original design is that the valve rectifier has been eliminated and replaced by a diode bridge arrangement. This is more compact and efficient than the valve rectifier used in the original design.

In practice, this set worked quite well and many stations can be heard on the broadcast band.

Dennis's Miniature DX Set

Dennis's Miniature DX Set from 1955 uses a similar circuit to Ray's but its execution is very different. That's because Dennis's interest in vintage radio leans heavily towards sets with beautifully-finished timber cabinets.

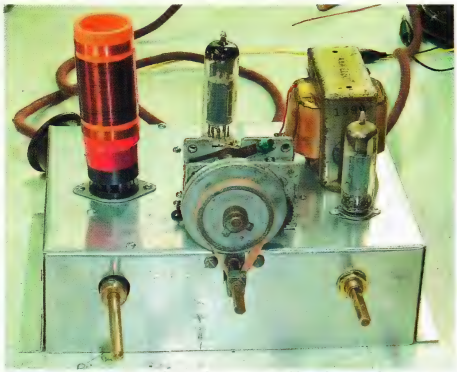
Many years ago, Dennis came across some information on a set called the "Aristocrat Three". During its heyday, this set was advertised as the "1931 Wonder Receiver" and one of its main features was its attractive tower-style timber cabinet.

Dennis decided to reproduce this cabinet for one of his own sets and because no dimensions were available, designed his replica just by looking at a photograph of the original. The cabinet was made from timber that Dennis recycled from some old furniture and is a tribute to his woodworking skills.

As well as functioning as a radio, the original set also had an "Eight Day Jewelled Movement Luminous Clock" and Dennis was able to obtain a clock that looked very similar. The dial-scale is also similar to the original but is made by Healing.

When the Hellier Award competition for 2009/2010 came along, Dennis decided that the Miniature DX Set would be suitable receiver to fit into his replica cabinet. The receiver is built on an aluminium sheet that has been cut, bent and riveted to make a conventional chassis.

The geared dial-drive system used by Dennis allows the Healing keyhole dial escutcheon to be used. The loudspeaker is mounted at the top of the cabinet facing upwards, as in the original "Aristocrat". In addition, the inside of the cabinet has been painted matte black – just like many sets of



Dennis's Miniature DX Set of 1955 also uses a set of five plug-in coils to cover the broadcast and shortwave bands. The rubber band fitted to the dial drive systems is a stop-gap measure only.

These are the remaining four plug-in coils for Dennis's Miniature DX Set (the fifth coil is shown in the chassis view above). Each coil is clearly labelled.

the valve era were. There is plenty of room for the chassis and there is also ample ventilation, as the chassis sits on raised wooden runners.

The circuit uses the valves originally specified for the Miniature DX Set, ie, a 6AU6 regenerative detector, a 6BV7 audio output (or alternatively a 6M5) and a 6X4 rectifier. The coil formers are made from old valve bases with electrical conduit glued to them. The five coils were then wound onto the conduits and terminated at the appropriate pins on the plugs.

During construction, Dennis fitted a valve that he believed to be a 6BV7 even though part of its type number had rubbed off. Unfortunately, the completed set refused work and after spending some time trying to locate the

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The high point of Dennis's set is its beautifully-crafted timber cabinet, complete with a clock and a keyhole dial escutcheon. The loudspeaker is mounted inside the cabinet facing upwards.

fault, he eventually took the set to a friend who pointed out the valve was in fact a 6BM8. This valve is a triode pentode and is quite a different beast.

Unfortunately, this can be a problem with used valves which have missing (or partially missing) type numbers. If you aren't certain, then it's a good idea to compare the unknown valve's internal structure with valves that have their type numbers intact.

Having finally identified the mistake, Dennis then had to fix the problem. He didn't have a 6BV7, so he rewired the valve socket to suit a 6M5. That proved successful – with a 6M5 installed and power applied, the set burst into life.

The underside of the chassis is not unduly crowded, although access to the valve socket pins isn't as easy as it is in the other sets. In addition, one electrolytic capacitor has heat-producing resistors mounted underneath it. Fortunately, the heat produced by these resistors is quite moderate but as a general rule, it's best to keep parts like valves and high-wattage resistors clear of other components to ensure long-term reliability.

One problem with Dennis's set is that he has temporarily "anchored" the mains cord by tying a knot in it, just inside the chassis. This was common practice back in the 1940s and 1950s but it's no longer acceptable and Dennis has promised to remedy this at the earliest opportunity.

Despite this, his set was judged to be the winner in other areas and it's not hard to see why, especially with that beautifully-crafted cabinet. SC

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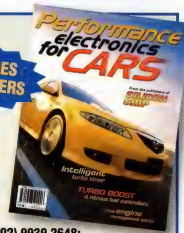

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WIB regulator gets hot

I recently put together the Web Server In A Box (WIB, SILICON CHIP, November & December 2009, January 2010) and I am very happy with its versatility. I constructed the kit as per the instructions as I always do and tested it according the instructions. Everything worked straight away, which doesn't always happen.

My question is regarding the LM317; it runs very hot to the touch. I understand they do get hot and that's the reason for the heatsink. I am just thinking of the small enclosure and the heat the device produces.

The kit is drawing 200mA but the input voltage is more than 9V from both of the two plugpacks I have tried. One was 11V and the other 14V. From what I understood of the LM317 it can accept an input voltage higher than I am using. Any help would be appreciated. (B. S., via email).

● While we did specify an input voltage from 6-9V, that does not necessarily mean that you should use a 9V plugpack. As you have found, a 9V plugpack typically delivers a lot more than 9V and so the regulator will run hot (when using a 9V plugpack). The best approach to reduce the heat generated in the regulator is to use a 6V plugpack. These will typically deliver around 8-9V. The lower the input voltage, the less heat will be generated.

Speed control for water pump

I wish to remove the engine-driven water pump on my car and replace it with an electric pump. I need a controller for the pump motor and have been looking at the High Power Reversible DC Motor Speed Controller in the August 2010 issue of your magazine.

A question I need to ask is this: can the speed set-point be derived from a temperature-related source? In particular, can I delete VR1 and use two thermistors in series such that a PTC one connected to an NTC one to give a facsimile of a potentiometer with the characteristic that the common or centre tap resistance moves like a pot and is related to temperature?

I'm thinking that this will be easier than using a thermocouple. For the pump I have, the motor speed will need to be 20% when cold (0-20°C) and rise linearly to 100% at 82°C and above.

I've not yet looked at any one type of thermistor to use. If you can recommend something I would appreciate that a lot. I have had experience in replacing the pellet in OEM temperature sensors, so packaging a thermistor is no problem here. (M. W., via email).

● The August 2010 controller is not suitable since the circuit relies on the resistance of VR1, the speed potentiometer, remaining at 5kΩ in total. A thermistor and fixed resistor or two thermistors (NTC and PTC) will not remain at 5kΩ over a temperature range. Nor will their total resistance will be linear with temperature.

The High-Current Motor Speed Controller from our June 1997 issue would be more suitable since the speed is voltage controlled. It is sold by Jaycar Electronics (Cat. KC-5225).

In this case, use a 10kΩ NTC thermistor for the connection between VR1's wiper and the 5V reference, with a 47kΩ resistor in parallel. A 4.7kΩ

Fooling A Car's ECU On Battery Charge Conditions

I need to run a current through my vehicle's current clamp, to fool the car's ECU into thinking the battery is either more charged or less charged than it really is, ie, the car has a current clamp on the negative lead, and I want to run a wire through the clamp and force a current through this wire, to change the current reading send to the car's computer.

This seems like an interesting requirement, in that I only need current, not voltage. I need no power at all, other than the tiny power required to cause some current through the wire (a few amps will be sufficient).

In practice, I'll loop the wire through the clamp a few times to increase the effective current.

Do you have any ideas on how to make a very efficient current source, ie, a current source that has as little power dissipation as possible? I guess what I am asking for is an ultra low voltage power supply that can act as a current source.

Note that I realise that if I just hooked this device up to the vehicle's 12V supply, the efficiency then becomes largely irrelevant. However, I like the idea of a small battery powered device that does not need to be connected to the 12V rail. (G. S., Ryde, NSW).

● Unfortunately, to have a current source of several amps, there must be some power drawn due to the losses in the current source and the voltage drop across the wire loop for the current flow. So unless the current is flowing through a zero-ohm resistance and the voltage is zero, there must always be some power dissipated.

A switchmode current source would be the most efficient. However, the most practical way is probably to loop several hundred turns of wire through the current clamp loop (using fine gauge enamelled copper wire). That way a small current would be multiplied. The current source would comprise the wire windings and you may also need a resistor to limit current.

Using The Ultrasonic Anti-Fouling Project As A Commercial Replacement

I have two questions about the Ultrasonic Anti-Fouling project (SILICON CHIP, September & November 2010). I have an F/G 37-feet Hunter yacht fitted with four transducers. The drive unit has burnt out. It is branded BARNIKIL and I have been unable to source a replacement from the original Canadian company. These look like the rear drive unit of a speaker epoxied to the hull. Will your system drive them?

Second, I want to ask about the physics of the transducer. A speaker is generally mounted on a solid platform to "shake" the air, not the speaker, and also to prevent the air slipping around the back of the speaker. A speaker completely embedded in concrete does not make much noise.

To "shake" a boat, the ideal would be to mount the front of the transducer to the hull and the back to a solid immovable object, say a pylon; not practicable. Next option is a solid baffle within the boat, block of concrete, solid table, engine block etc. Having the transducer solidified in epoxy does not sound right to me. Could you please comment? (D. H., Vale Park, SA).

- Our unit is only suitable for driving piezoelectric transducers, not those with "voice coils".

However, while transducers similar to loudspeaker drivers were used in early ultrasonic anti-fouling systems such as those used on naval ships, we would be surprised if they have been used in recent years because they require far more power to drive than piezo transducers.

One way to find out would be to measure the transducers themselves. If they have a low resistance, ie, anything under 100 ohms, then they are coil transducers. But it is more likely that you will find that they are piezoelectric and this will be confirmed if they have substantial capacitance and very high resistance. For comparison, the transducers employed in our ultrasonic system (and equivalent commercial units which are very similar) have a capacitance of between 3000pF and 4000pF (3nF to 4nF) and a very high resistance of many megohms.

If your transducers fall into this capacitance range, then there is a fair chance that they can be satisfactorily driven by our control unit. However, you would need one control unit for each transducer, ie, four control units in total.

As far as "shaking" the hull is concerned, the transducer can be regarded as being closely coupled to the hull and it shakes its "back end". This reaction is coupled back into the hull. We assure you that it works.

Ultrasonic Anti-Fouling For Catamarans

I have an 11-metre sailing catamaran and am looking into using your ultrasonic anti-fouling kit. The hulls are solid fibreglass below the waterline and foam sandwich above.

To use your system would I need two control units or will one unit drive the four transducers I would need? I have a friend with a 15-metre aluminium catamaran. Would this system be suitable for him and what gear would he need? (M. D., via email).

- Your hulls will be fine for ultrasonic anti-fouling but you will need one transducer and one control unit for each hull of your catamaran. For a 15-metre catamaran, you would need four transducers and four control units.

In other words, you need a separate control unit for each piezoelectric transducer.

resistor should then be connected between the wiper position and ground. As the thermistor heats up, its resistance will drop, increasing the motor speed from about 10% at 20°C to about 82% of full speed at 85°C.

Speed control for oil pump

We wish to control the speed of a 24V DC motor with a rated amperage of 20A. This motor is driving an oil pump at 800 RPM at full power. We need to vary the speed to allow the oil pressure to rise and fall to suit the flow requirements applied by the system. We have purchased the High-Current 12/24V Speed Controller (SILICON CHIP, July 1997) from Jaycar (Cat KC-5225).

The instructions state that for 24V operation we need an MTP60N06. When queried, the sales person at Jaycar stated that all the components were included and that Jaycar do not stock MTP60N06. He also stated that we didn't need the two MUR1515s and that Jaycar didn't stock these also. Is this correct?

We would greatly appreciate assistance in getting this unit going, as the project it is being integrated into a very important development, of which the oil pump is the central controlling element. (A. R., Dandenong, Vic).

- The MTP60N06 is an older type number (since the project was published in 1997). The IRF1405 (Jaycar ZT-2468) is now recommended for high-current 24V use. Two should be installed on the PC board. Diode D2 (MUR1515), which goes across the motor terminals, should be included in the kit and only one is required.

Pan & tilt for camera

I enjoy the magazine, mainly for Leo Simpson's comments and the how things work type articles, and have finally gotten round to building the Bi-directional Motor Speed Controller of December 2004. It seems like the ideal circuit to drive pan and tilt on a camera head and does work as claimed except that all the control is crammed at the ends of the pot with a huge, maybe 120°, dead spot in the centre of the pot. This makes it very hard to control a camera.

I've looked at the outputs of the LM324 on a scope and the motor does start to turn almost as soon as a pulse appears, although one pin seems to have a good clean pulse while the other seems to have a lot of hash. Ideally I would like to spread the control over more of the pot and reduce the dead spot in the middle. Have you any suggestions please?

Otherwise keep the information coming and don't let anybody gag Leo just because his only qualification is in electronics. Somebody has to tell it like it is. Politicians won't. (G. B., via email).

● It would be pretty hard to make the Bi-directional Motor Speed Controller work well as a pan and tilt control. A much more practical method would be to use a circuit based on radio control servos which use a 1ms pulse.

We had a project to control two servos for just your application in the January 1998 issue. It was an Oatley Electronics project and would probably have been discontinued long ago although the circuit, based on a 74C14 Schmitt trigger, is still valid. We should point out that pan & tilt controls are also available on eBay.

High-frequency power transformer

I am investigating the possibility of having a variable output from a ferrite transformer working on a variable frequency. The wattage has to be around 200W and the transformer has to be small.

One application I already know of in the workplace is in inverter welders where the throughput is about 3600W and the transformer is only about 60mm cube. The object of the exercise is to increase the frequency to obtain a higher voltage output and working around a frequency of about 5kHz. (D. B., Warwick, Qld).

● We are not sure of the output voltage you require. We did publish a 200W 12V to 240VAC inverter in February 1994 and its voltage can be adjusted by altering the pulse width applied to the transformer. The frequency does not alter the voltage.

Note that 5kHz is a relatively low frequency and ferrite transformers generally operate above 20kHz and up to 1MHz.

12V guitar amplifier application

I recently purchased the 12V Mini Stereo Amplifier from Jaycar (Cat. KC-5495). Will this amplifier run guitar as the input and if so, will it run from 9V? If not, how can I make it work? (R. E., via email).

● While the amplifier will run off 9V, it won't develop much power and a typical small 9V battery will not last very long powering it.

We recommend that you instead use a small 12V SLA (sealed lead acid) battery. For example, the Jaycar SB2486 (7.2Ah, $24.95) will allow the amplifier to deliver reasonable power for quite a long time (probably all day, depending on how hard it is driven). It weighs 2.2kg though. If you need something lighter you can try the Jaycar SB2480 (1.3Ah, $19.95) which weighs about 570g but this may only last a couple of hours and possibly more, if the output is not very loud.

These can be charged using virtually any lead-acid battery charger but some care must be taken to avoid overcharging them. Jaycar sell a number of suitable chargers (eg, MB3517 or MB3526). You must also avoid discharging an SLA battery below 11V because that normally means death (for the battery, not you).

As for plugging a guitar in directly, it depends to some extent on the type of pick-up. Usually, guitars have a relatively high output impedance and a low signal level. You can certainly try plugging a guitar directly into the amplifier and you should get some sound out but it may be too quiet for your liking. Changing the volume potentiometer to a 100kΩ logarithmic type will increase the input impedance of the amplifier and that may help

Feedback On The Ultrasonic Anti-Fouling Project

I have now built and installed two Ultrasonic Anti-Fouling kits (SILICON CHIP, September & November 2010) in my catamaran and they appear to be working normally. However, at the end of the assembly in both cases I have a 0.1Ω resistor (I think? grey or brown with one black stripe) left over. There is no mention of it in the text and I am unable to locate its position on the circuit board. Can you please explain its usage?

I also would like to make the following comment: the wire used in marine installations should be tinned copper not plain copper as it will corrode in less than two years.

● Thanks for the feedback. The extra resistor is in fact a "zero-ohm" link which Jaycar have thoughtfully supplied in the kit so that you don't have to make one.

While tinned copper wire is now recommended for use in boats and is certainly desirable, it is by no means universal even in new boats and we think your prediction about corrosion in less than two years is a little pessimistic. However, a number of readers have made a similar suggestion and we have passed those comments on to Jaycar.

Encapsulation Problem With The Transducer

I have been happily completing the Ultrasonic Anti-Fouling kit and everything proceeded well. I used the mould release on the stretched cling-wrap, re-stretched again and fitted the 50mm BSP male valve socket. All seemed OK, so I poured about 2mm of potting mix into the transducer as directed, then completed the potting.

The pour went well and when cured there were no air bubbles in the top and I was very happy with the effort. After it was fully cured, I unscrewed the fitting with some trepidation but the result was not as expected. There were some creases spoiling the required smooth surface because the cling-wrap had distorted.

Is there anything I can do to overcome this calamity? Will it affect the proper operation of my working kit in the vessel? Or is it time to trash it and start again? (L. M., via email).

● Do not despair – well, not yet anyway. If the crinkles are very slight, which is probable, then you need not worry. Just be sure to coat the face of the encapsulated transducer liberally with a non-hardening grease such as Fix-A-Tap. This is applied to fill any voids between the transducer's face and the hull and it should fill the crinkles you are worried about.

On the other hand, if you think the crinkles are quite severe, you could use a sharp wide-bladed chisel to carefully shave off the high spots.

Standby Current For Relay Circuit

I wish to upgrade my car stereo head-end unit. My car is a 2007 model and the original stereo is integrated into the car's central controller and as such has some interesting wiring that does not seem to conform to the norm.

I can identify all that I need with the exception of a 12V supply that is switched on and off by the key from the accessories position (as you would normally have). I have found wires that provide this source and I want to use one to trigger the DC relay switch using a separate fused supply to isolate the car stereo load and prevent potential faults. The DC relay switch will be permanently connected to the battery, fused, of course.

My question is this: what is the current requirement for the DC Relay Switch in "standby" mode? You say that the board requires 150mA to operate but I assume that this also includes the current to operate the relay.

The relay when operating will normally be with the engine running which is not a problem. I am concerned about the constant load the board will present to the battery in standby. (P. M., via email).

● The circuit draws no current until there is voltage applied to the input terminals of the DC Relay Switch. Then the current drawn by the circuitry is mostly due to the relay coil. There may be a small leakage current in standby at around 100nA (0.0000001A) due to dark current through the 4N28 optocoupler transistor. In other words, standby current is negligible.

although it is still far from ideal.

If it is still too quiet, then you will need to add a preamplifier between the guitar and the amplifier (it could be built into the same case). One possible candidate would be the High-Performance Microphone Preamplifier published in the September 2010 issue (Altronics Cat. K5514). This provides adjustable gain from 3-111 and is quite small, so it could be fitted into the amplifier's case.

Connect the guitar input to the microphone preamplifier input, then the microphone preamplifier output to the amplifier board inputs. It can run off the same power supply. The preamp gain knob does not need to be accessible outside the case as you can still use the volume knob.

We have also published various guitar mixers and other suitable preamplifier projects in the past, such as the Versatile 4-Channel Guitar Mixer in June 2007. This is available as a kit from Jaycar (Cat. KC-5448).

Tempmaster has occasional relay chatter

I built the Tempmaster Fridge Controller Mk II and it's working fine – well usually. Occasionally it has some severe "relay chatter" – rapidly switching on/off around 10 or so times a second for anywhere from one to five or so seconds. Any idea why it would do that, and not always, but sometimes? (S. B., via email).

● This kind of 'occasional chattering' is usually caused by noise pulses radiated from the 230VAC power line to the 'fridge', when the relay turns off the power to the compressor. The 'occasional' nature of the effect is probably due to the exact time that the relay turns the power off, relative to the zero crossings of the 230VAC waveform.

In most cases, fitting a line filter in series with the 'fridge' power lead will prevent the chattering from occurring. However in stubborn cases, you can make the Tempmaster Mk2's internal comparator a little less sensitive to noise pulses, by increasing its hysteresis. This is done by replacing the 1.2kΩ resistor currently connecting pin 3 of IC1a to the centre pin of the LK1 header with one of higher value, such as 1.5kΩ, 1.8kΩ or 2.2kΩ.

Headphone booster for MP3 player

Having recently retired, I often take my iPod and a book, find a quiet spot and listen to music or watch a movie. However, I find that the volume level from the iPod is insufficient for comfortable listening.

Is it possible to feed the earphone output of the iPod into the Champ 0.5W amplifier (Silicon Chip, February 1994) and then feed the amplifier's output to a single magnetic earpiece.

I realise that this would give a mono output and that I would need two amplifiers for stereo but for the limited usage, mono is quite satisfactory.

Also in view of the limited usage, I was thinking about using a 9V battery or perhaps a number of AA cells in series to power the amplifier. Any advice or advice on a better way of doing it would be appreciated. (K. J., Woodbine, NSW).

● If you have a genuine iPod (ie, Apple Classic, Nano, iPod Touch etc) then the output level from these is more than sufficient to drive the supplied ear buds to excessive loudness levels. If you have one of these, check that the ear buds are working correctly or use 32-ohm headphones.

If the unit you have is different to the Apple iPods, then the levels may not be sufficient, especially if it is one of the single AA or AAA cell powered types of MP3 players.

In this case, the level could be boosted with the Champ which can then drive either 32Ω or 8Ω headphones. A 9V battery may not provide sufficient playing time though and we would recommend using either a 6V or 9V battery made up from four or six AA cells.

You may also consider using high-efficiency headphones that attenuate ambient sound so that in the main, only the sound from the headphones is heard. This may allow your player to provide satisfactory sound levels without any extra amplification.

Hand-held hot-wire cutter

In the December 2010 issue of Silicon Chip you have a Hot-Wire Cutter. I know that you have it mounted to the table. As a model railway maker, I use polystyrene foam for the hills. There are many expensive items that can shape the polystyrene but yours seems more simple and practical.

My question is, could you mount this on a hand-held device that still gives tension? The device I have in mind is similar to this: **http://www.gosfordhobbies.com.au/shop/images/P/woost1435.jpg** That way you could cut the mountains easier by moving the

cutter in whatever direction you need it to go. (J. R., Stratton, WA).

- You can certainly adapt the Hot-Wire Cutter to a single-handed cutting tool, as demonstrated by one of the letters on page 6 of this issue. The principle of the hot wire cutter can be extended to a lot of different plastic cutting applications.

Balancing fridge & freezer temperatures

I have been using the LCD Thermometer/Thermostat (SILICON CHIP, March 2010) in my fridge for many months. It has been holding the temperature at 4°C, ie, 3.5°C minimum and 4.5°C maximum. I have been slow to realise that items in the freezer section have been slowly thawing.

Recently, the temperature in the freezer has been between -1°C and -9°C. I presume that the compressor is not running long enough to bring the temperature down to -18°C (or more).

As there is no sensing in the freezer, can I assume that the LCD Thermometer/Thermostat was not intended for general purpose freezer/fridges in the home kitchen? I own a separate chest freezer in another room which is used for long-term freezing. Can I presume that all items in the kitchen fridge/freezer should be transferred to the separate chest freezer? (D. V., Nagambie, Vic).

- That's a tricky problem because the refrigerator is using one adjustment (compressor duty cycle) to control two output variables (fridge and freezer temperature).

Since there is a greater temperature difference between the freezer and ambient air compared to the fridge, the freezer loses heat faster. To compensate, normally the cold air from the heat exchanger is routed through the freezer section first. The cooling ratio is generally set by an adjustable air valve which controls how rapidly the cold air passes from the freezer to the fridge section although it is possible that some models have a fixed valve.

It seems that the cold air may be passing through your freezer section too quickly. If you have a freezer/vent adjustment, use this to set the freezer to a lower temperature (ie, by further shutting down the vent).

Note that it's quite normal for the freezer to vary in temperature during the frost-free cycle, since the evaporator is heated to melt the ice from the coils.

Using the Beam-Break Trigger with an air-rifle

I have a question about the Beam-Break Trigger from the June 2009 issue. I am trying to use an Airsoft gun (**http://www.crosman.com/airsoft/rifles/SASR3**.) It fires 6mm round plastic pellets at about 240 feet/sec.

I have been using the sound trigger from the Photoflash Trigger kit (SILICON CHIP, February 2009) and it works quite well but there is a problem. The Airsoft gun uses a spring so there is some variability in the velocity. When the target is about 60cm from the barrel and the timer set to about 24ms, the pellet can vary by as much as 10cm, making it difficult to get the target lit at the right moment.

I thought using the Beam-Break Trigger kit may give better results as it would be triggered after the spring has fired the pellet. However, the Beam Break Trigger is not fast enough to be trigged by the pellet. It works fine when I pass a finger through the beam and when I drop the pellet through the beam. Is there any way to make the detector more sensitive?

I found this detector that is used with the Camera Axe at: **http://www.glacial-wanderer.com/hobbyrobotics/?p=446**

. . . *continued on page 103*

Notes & Errata

USB Data Logger, December 2010 & January 2011: to improve filtering of the +3.3V supply rail, the 22µF tantalum capacitor on the output of REG1 should be changed to a 220µF 10V low-ESR electrolytic (Jaycar RE-6300). This applies to both the circuit diagram in Pt.1 (December 2010, page 38) and to the overlay diagram in Pt.2 (January 2011, page 35).

Note that there are two 22µF tantalum capacitors shown adjacent to REG1 on the overlay. The capacitor on the left is the one to change. The parts list in Pt.1 should be amended accordingly.

Digital Lighting Controller, October-December 2010: there are several errors in the PC board overlay diagram on page 28 of the November 2010 issue. The resistor immediately to the left of D4 should be 390Ω, not 100Ω. Of the three nearby 10kΩ resistors, the right-most two should be 3kΩ.

The circuit diagram in Pt.1 and the boards in kits and from RCS Radio have the correct values.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

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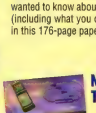

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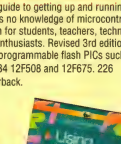

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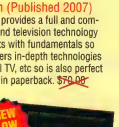

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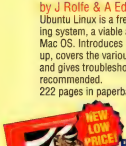

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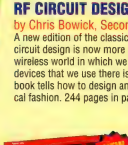

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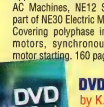

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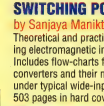

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Ask SILICON CHIP – continued from page 99

It has a fall time of 15ns. Would it be possible to use this detector instead of the one in the kit? (R. K., via email).

● You probably could achieve faster response from the Beam-Break Trigger unit by substituting the faster photo detector you propose – it's certainly worth a try.

You might also be able to achieve a small improvement in sensitivity by reducing the resistor between pin 2 of IC1a and the 1.0V reference voltage, eg, from 1kΩ to 470Ω.

Ultrasonic circuit comparison

I am comparing the Ultrasonic Cleaning Bath (Silicon Chip, August 2010) and the Ultrasonic Anti-Fouling (September 2010) circuits. Why does one have a "regular" 7805 regulator and one have a "TDA" LDO type regulator?

Also, some boats are 24V so what could be done to make the unit run from 24V? (M. D., Perth, WA).

● That is a good question. The reason that the Ultrasonic Anti-Fouling project uses the TL499A rather than a 78L05 is not because the TL499A is a low-dropout type – it isn't. There are actually two reasons and both are related to the fact that the Anti-Fouling unit is designed to run off a battery.

It is generally good practice for a battery-powered device to have a low-battery cutout feature. This prevents the battery from being damaged or destroyed by over-discharge. It is especially important for this project because it would be left running unattended for long periods and there are various reasons why the battery charger may stop working (eg, it could be recharged from solar panels and there might be many days of cloudy weather in a row).

Ideally, the unit will consume very little power when the low battery cut-out is in effect. If we had used a 7805/78L05 regulator then that would add 3-5mA to the current consumption of the unit even when the low-battery cut-out is in effect. That's because the micro needs power whether or not is it actually running the anti-fouling and this is provided by the regulator.

The TL499A, on the other hand, has a quiescent current of just 15µA and this means that when the low battery cut-out is engaged, the current drain on the battery is so low that it will last for months without a recharge. In other words, the TL499A is a low quiescent current regulator but the 7805/78L05 is not.

The second reason is that the low-battery cut-out needs a reference voltage to compare with the battery voltage. The output of a 7805/78L05 is accurate to within about ±5%. This is not good enough for lead-acid battery voltage monitoring as this would equate to a cut-out voltage of say 11.5V ±0.5V and it's even worse when you consider the effect of resistor tolerances.

Since the TL499A is an adjustable regulator, it is possible to trim its output much closer to 5V than the 7805 and so the low battery cut-out voltage can be set with relative accuracy.

As for running the Ultrasonic Anti-Fouling unit from 24V, it could be modified to do so but there would need to be a few changes. First, the transformer would need to be rewound with twice as many turns on the primary windings. This would be necessary so that the output voltage was kept the same with the input voltage doubling. The Mosfets should handle the increased voltages as they are.

You would also need to replace the 2200µF 25V capacitor with a 35V type and similarly replace the 100µF 16V capacitor on the TL499A with a 35V type. The TL499A can handle a 24V (nominal) input but this would reduce its capability to deal with voltage spikes as it would have less headroom.

The low battery cut-out sensing divider would also have to change to suit the higher voltage which is just a matter of changing it from being a 1/3 divider to a 1/6 divider. In addition, the power LED resistor should be increased from 4.7kΩ to 10kΩ to keep the LED current the same. SC

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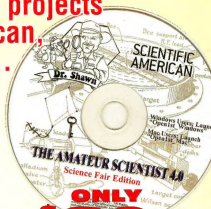

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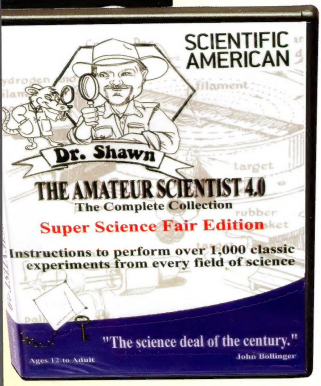

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Includes 5 piece 8mm turning tool set

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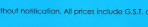

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